CHEM 2311 Final Review Worksheet

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

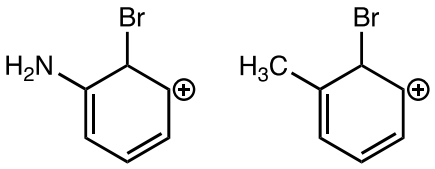
3. A particular signal within a ^1H NMR spectrum has the shape of a quartet. How many equivalent (or nearly equivalent) protons are within coupling distance of the protons corresponding to this signal?

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

4. 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

5. 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

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

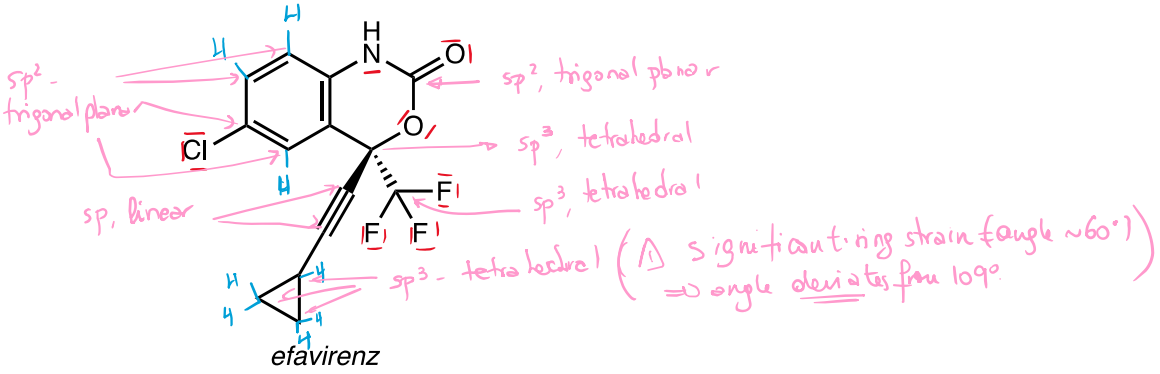
a. CH_3Br
b. CH_3CH_2Br
c. Br_2
d. $(CH_3)_3CBr$
e. $(CH_3)_2CHBr$

7. 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

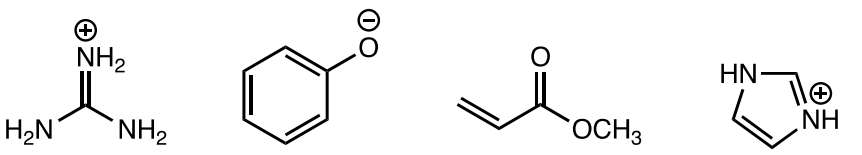
II. Short-answer Questions

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.



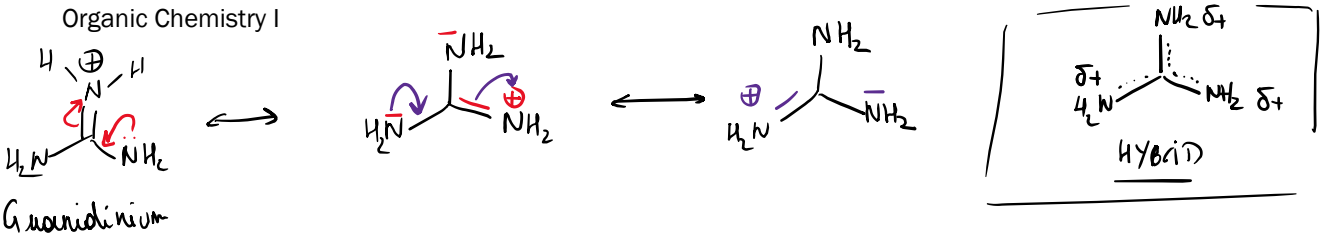
efavirenz

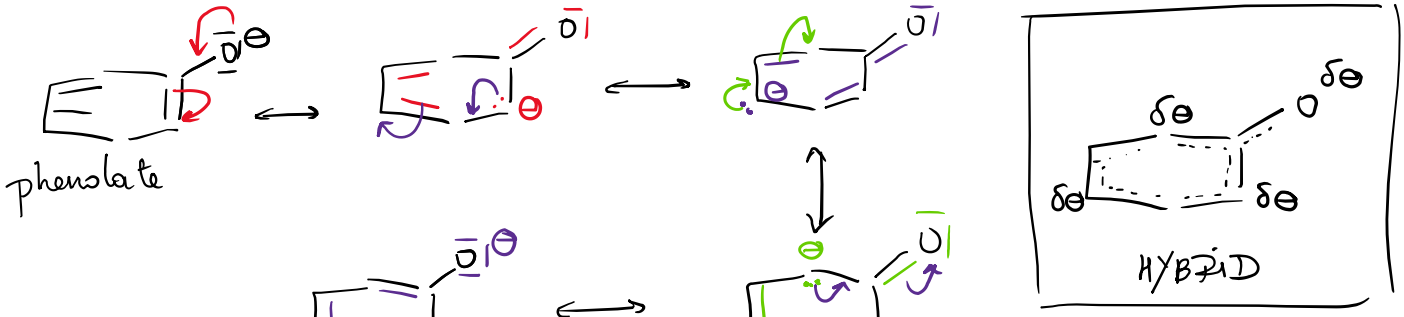
2. Draw all contributing resonance forms of the molecules below.

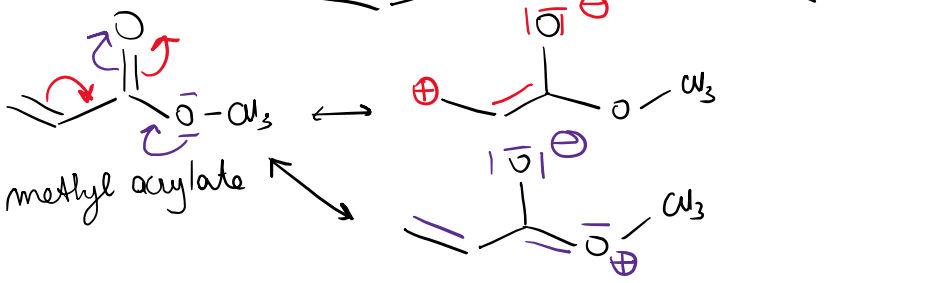


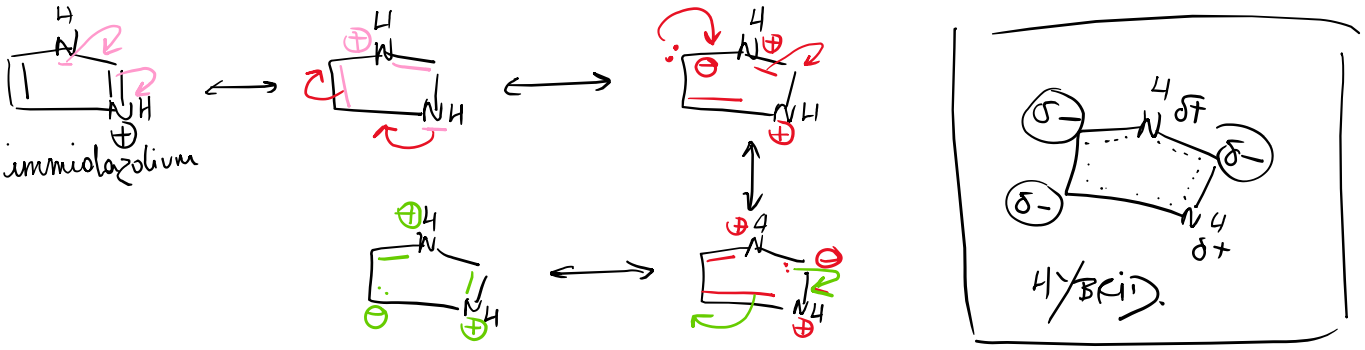
guanidinium *phenolate* *methyl acrylate* *imidazolium*

(only e⊖ move!) resonance forms are connected by "↔"

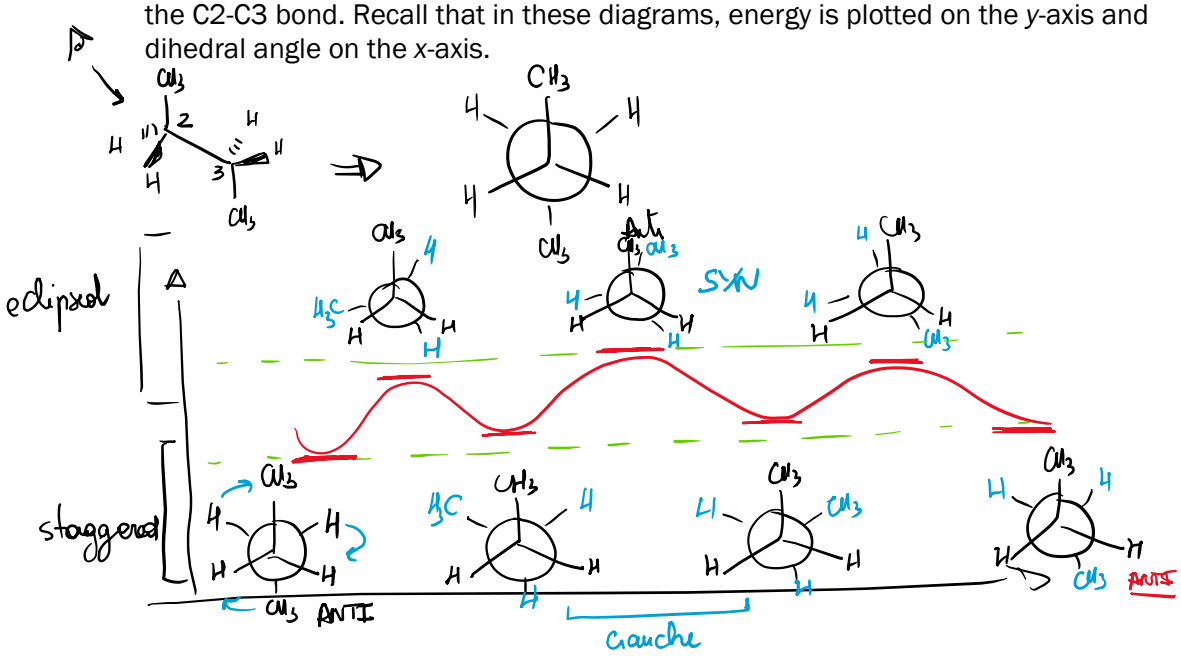

Guanidinium
HYBRID


phenolate
HYBRID

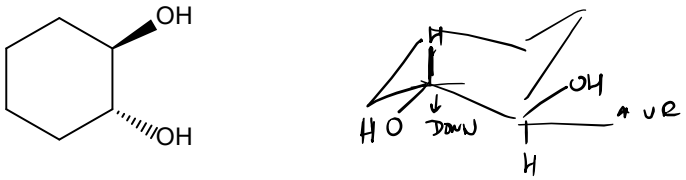

methyl acrylate
HYBRID


imidazolium
HYBRID

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.

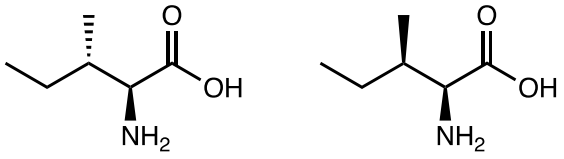


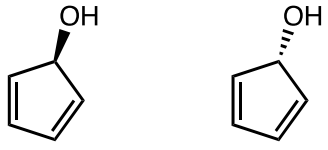
4. Draw the most stable chair conformer of trans-1,2-cyclohexanediol.

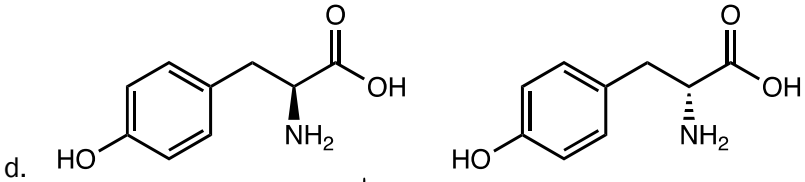


5. Identify the stereoisomeric relationship (same, different molecules, enantiomers, diastereisomers) between each pair of molecules below.

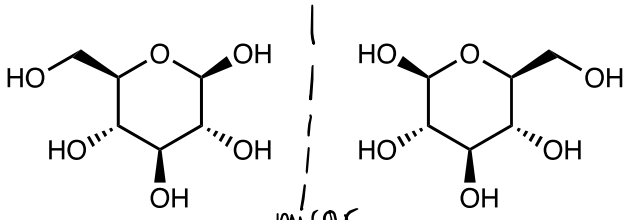
a.  same (NOT chiral)

b.  diastereoisomer

c.  same (NOT CHIRAL)

d. 

enantiomers

e. 

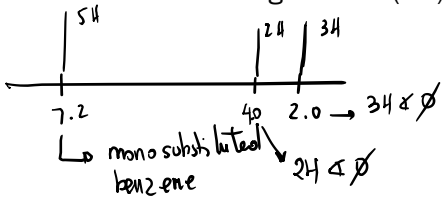
enantiomers

mirror plane

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

a. $C_9H_{10}O$

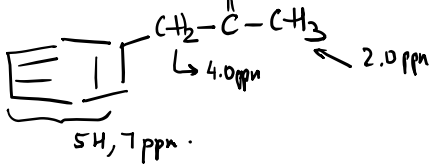
^1H NMR Spectrum
singlet δ 2.0 (3H)
singlet δ 3.75 (2H)
singlet δ 7.2 (5H)



Infrared Spectrum (Key Peaks)
3100, 3000, 1720, 740, 700 cm^{-1}

DoU = $\frac{(9\times2)-10}{2} = 4$ ⇒ Aromatic ring

IR: 3100, 3000 ⇒ C–H + C–H (sp^2 + sp^3)
1720 ⇒ C=O



5H, 7 ppm.

b. $C_5H_7NO_2$

^1H 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}

DoU = $\frac{10+2+1-7}{2} = 3$

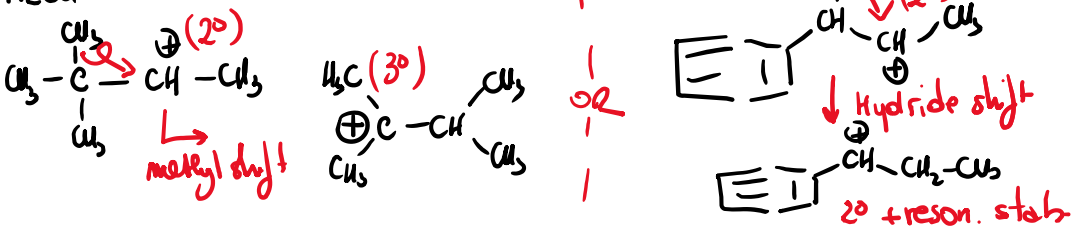
IR ⇒ 2980 → $C_{sp^3}H$
2260 → triple bond C≡C

NMR –
1.2 – 3H – t ⇒ 3H & 2H
3.5 – 2H – s ⇒ 2H & Ø
4.2 – 2H – q ⇒ 2H & 3H
seeing each other ⇒ CH_3-CH_2-

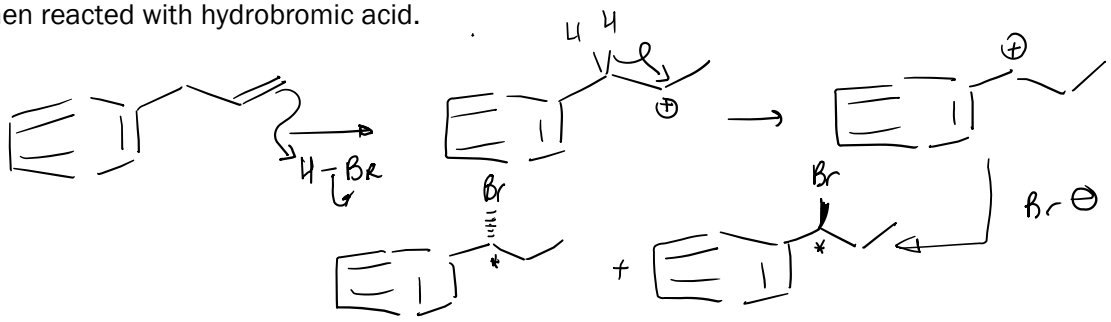
$CH_3-CH_2-C\equiv C-CH_2-NO_2$

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.

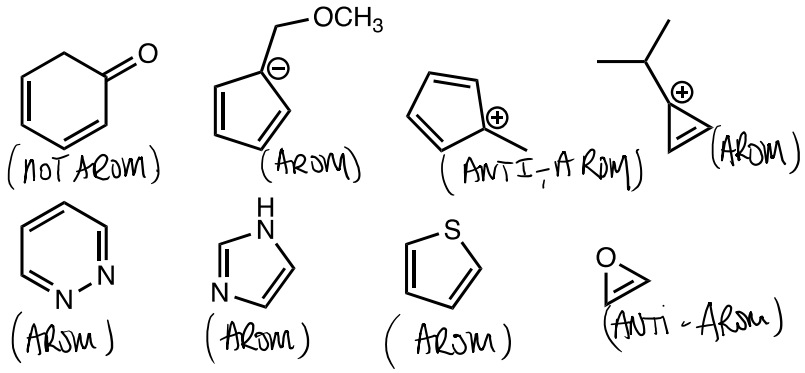
think 2° C⊕ ⇒ going to a more stable structure 3° or resonance stabilized



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

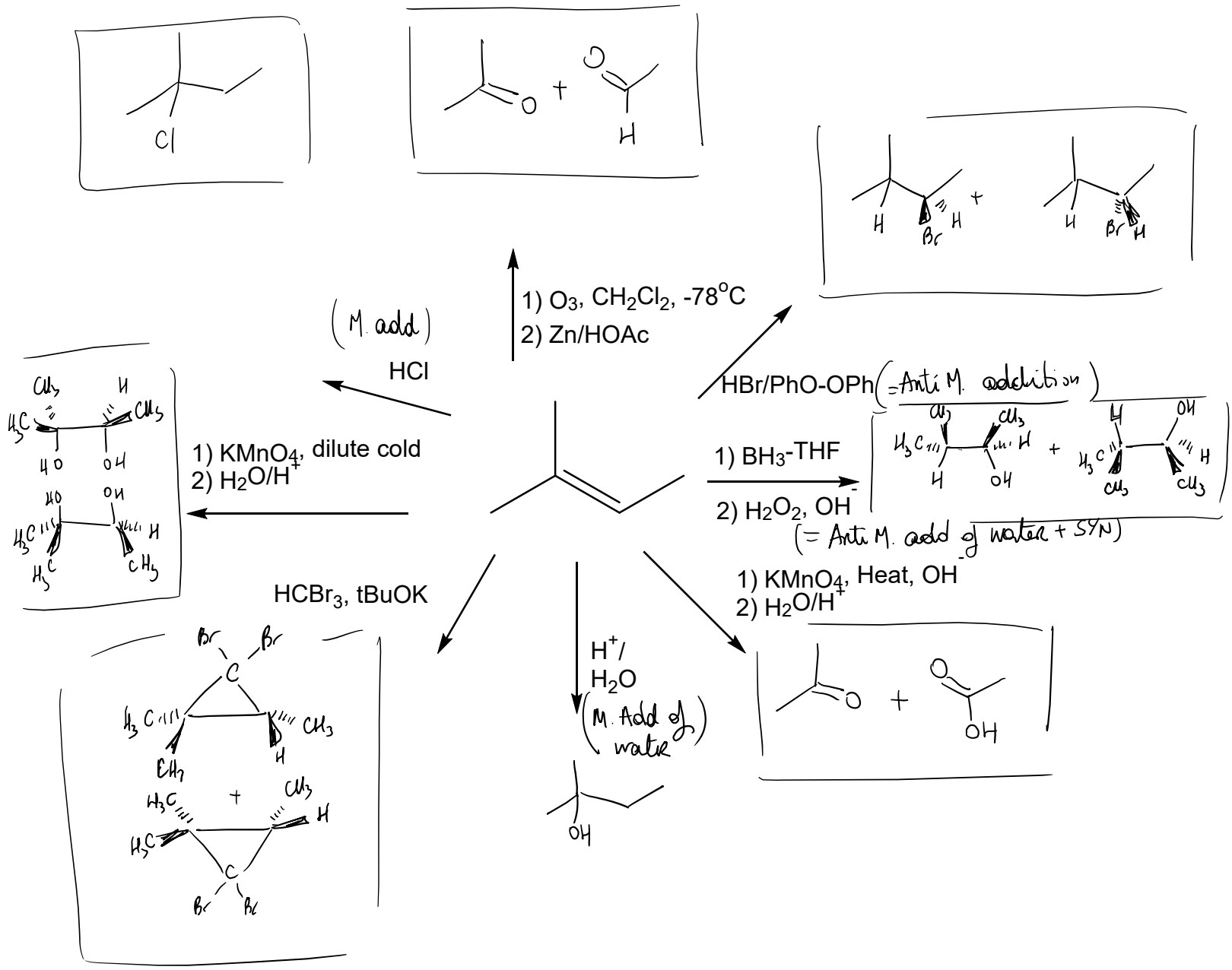


9. Determine whether each of the molecules below is aromatic, antiaromatic, or nonaromatic.

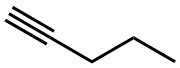


III. Write Reagents and/or Predict the Products

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

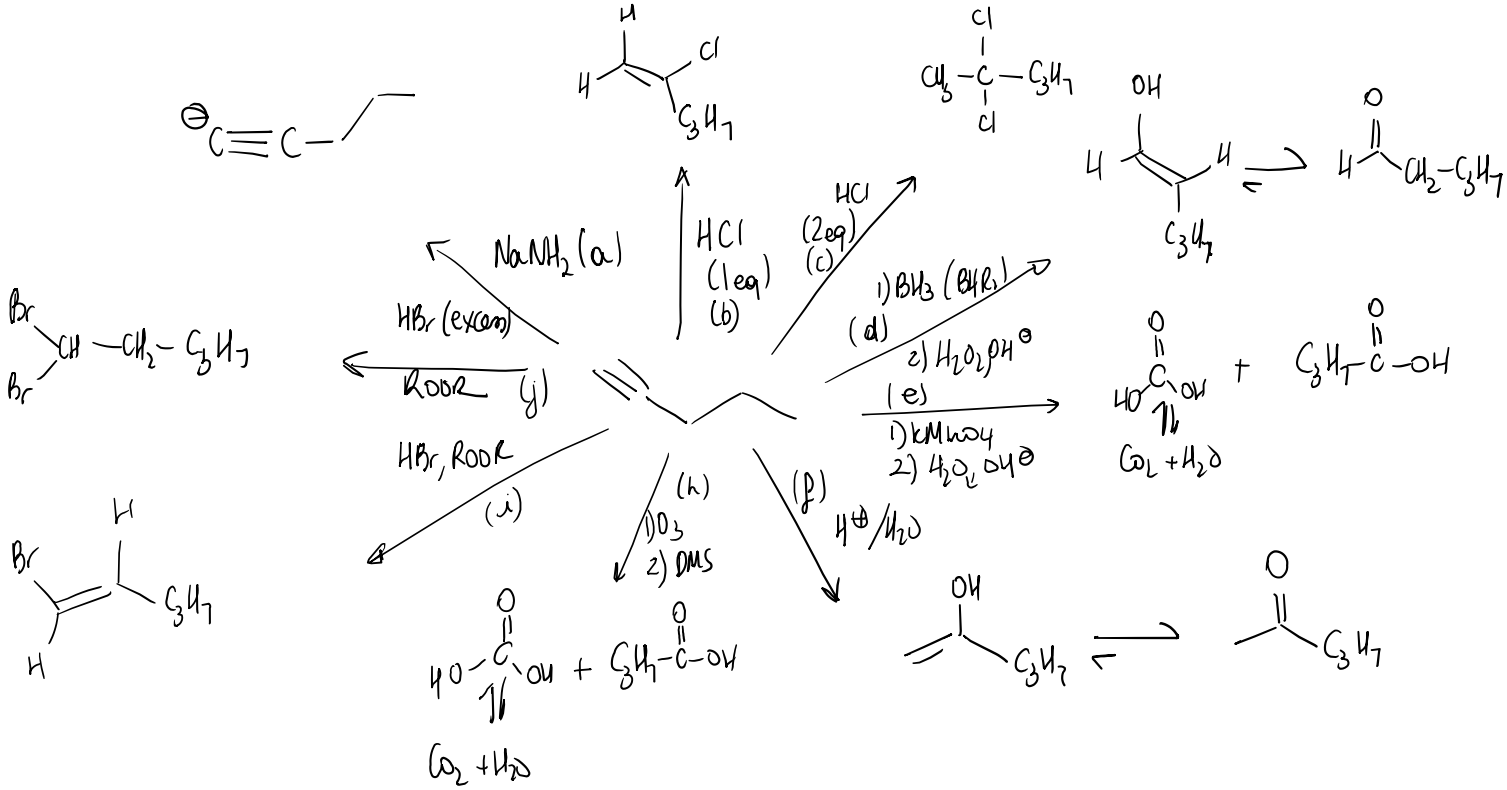


2. Write the reagents and draw the products for each of the following reaction types, starting from 1-pentyne. Include stereochemistry where necessary.



1-pentyne

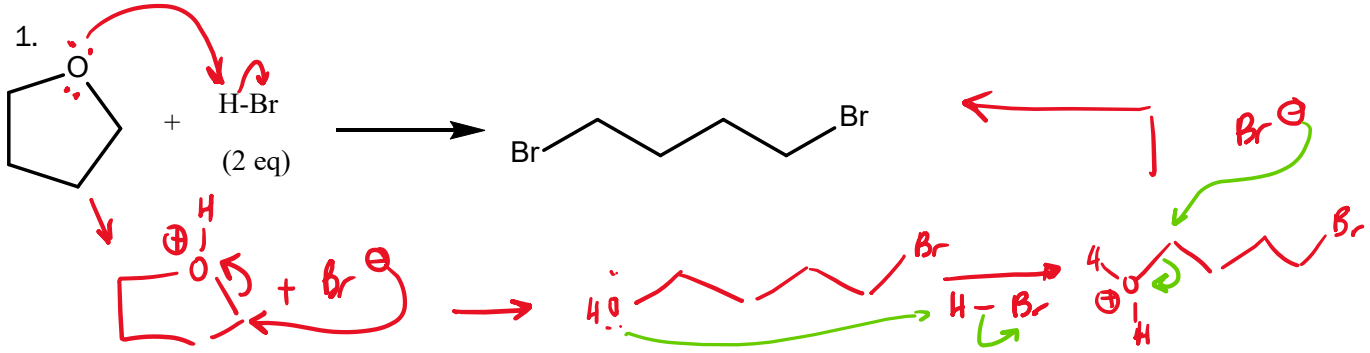
a. Deprotonation
b. Ionic hydrochlorination
c. Ionic hydrochlorination (2 equivalents)
d. Hydroboration-oxidation
e. Oxidative cleavage
f. Acid-catalyzed hydration
g. Oxymercuration-demercuration
h. Ozonolysis
i. Radical hydrobromination
j. Radical hydrobromination (2 equivalents)



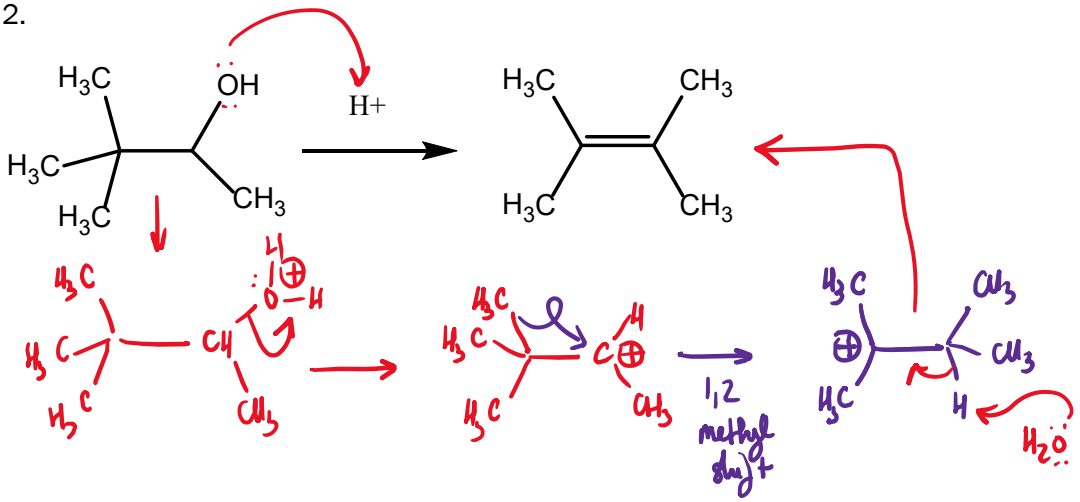
IV. Reaction Mechanisms

Propose mechanism for the reactions below

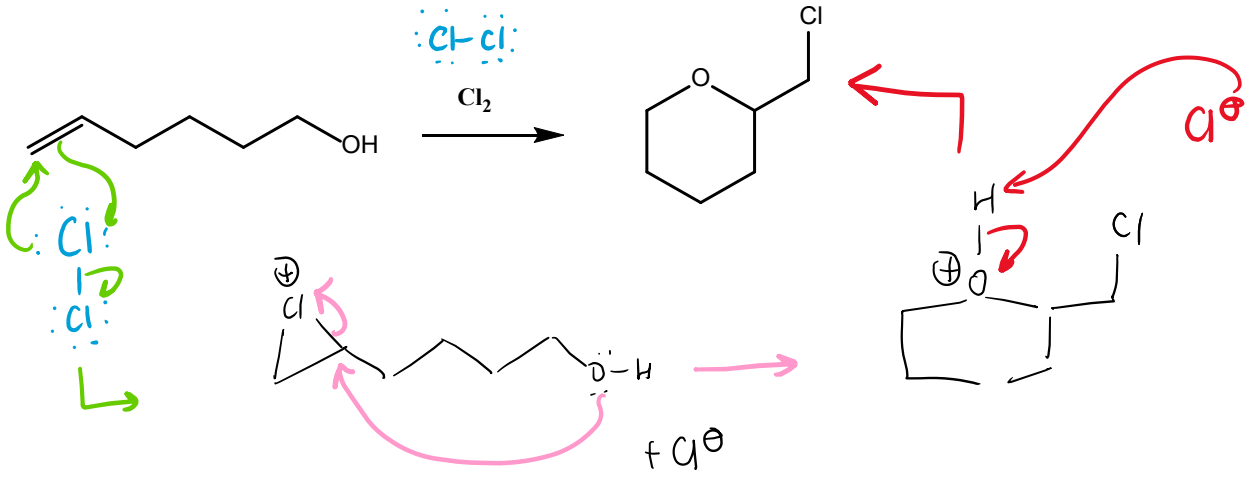
1.



2.

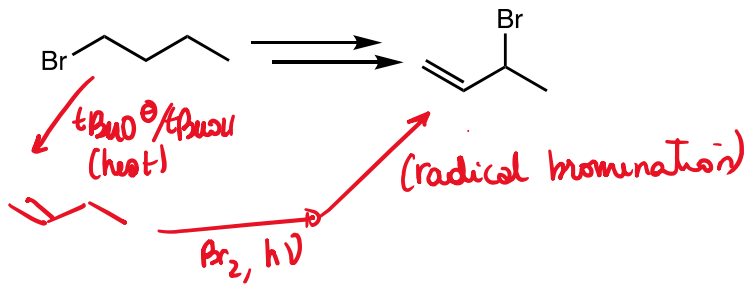


3.

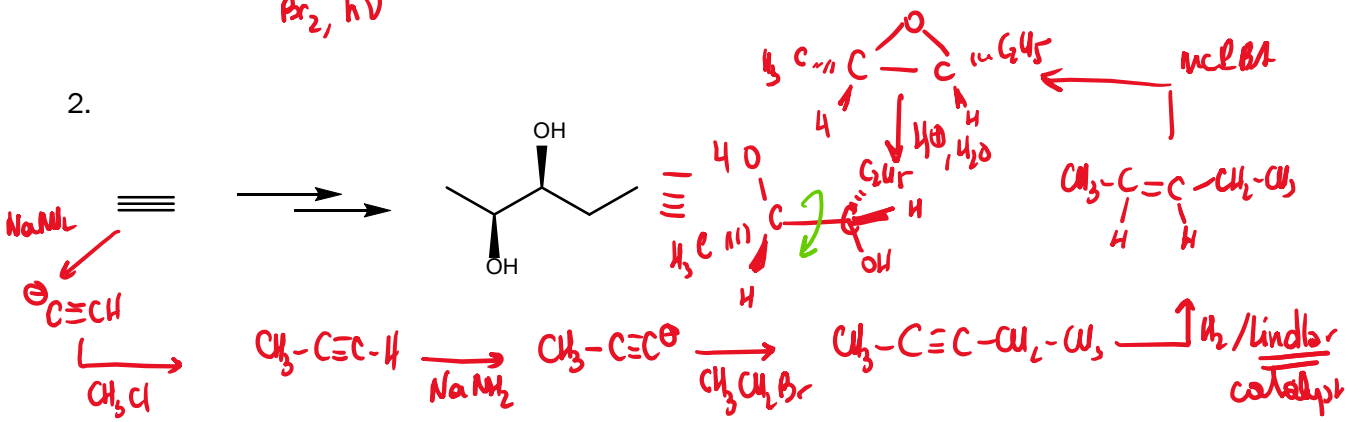


V. Multi-step Synthesis

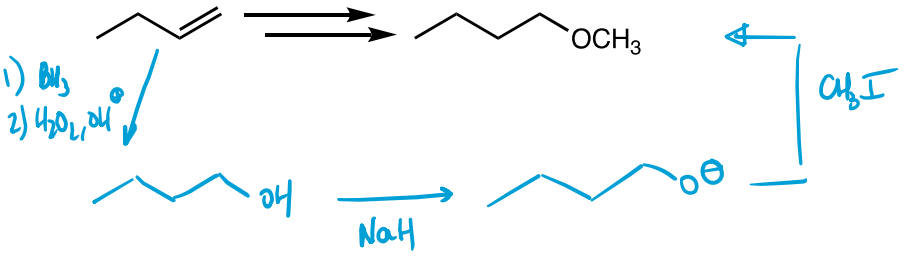
1.



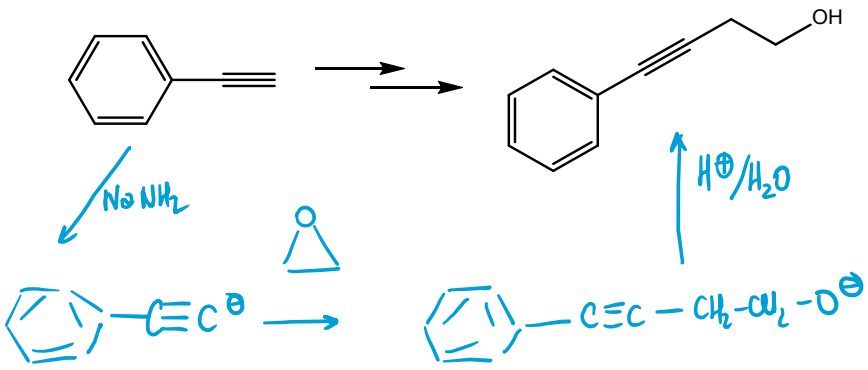
2.



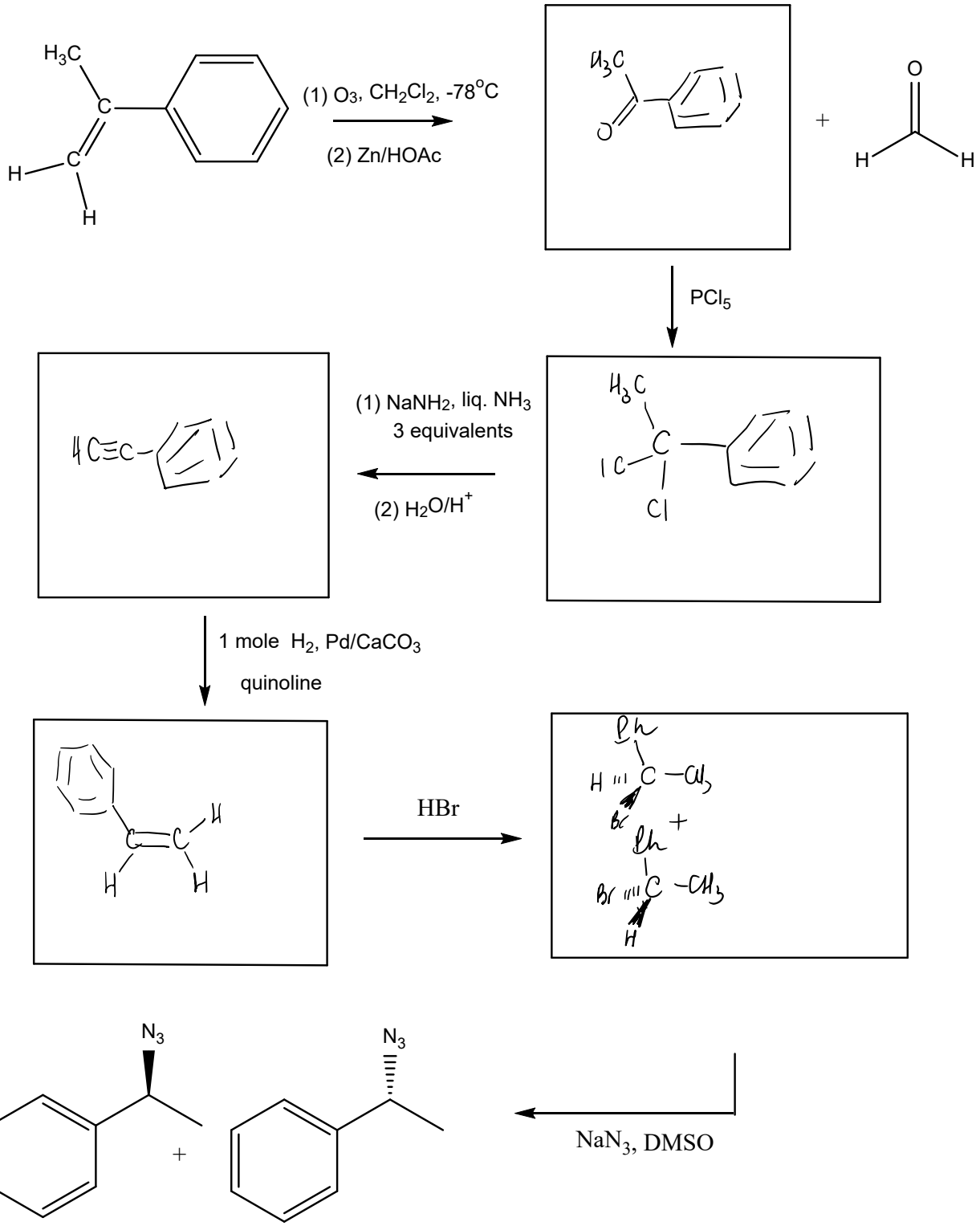
3.



4.



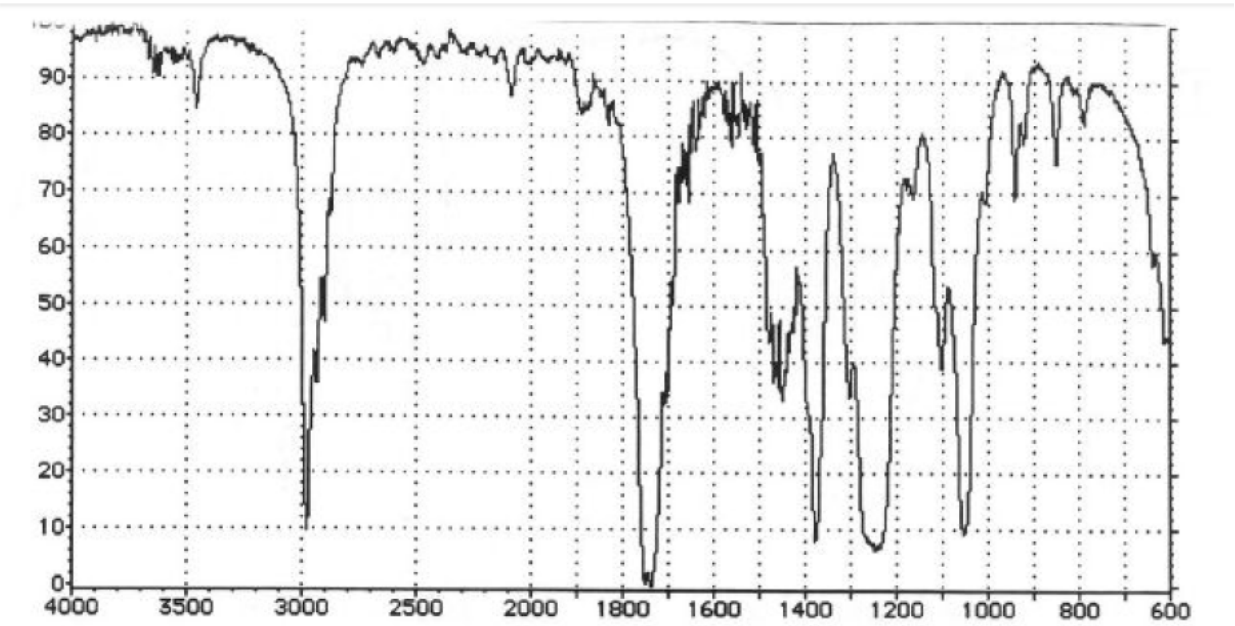
Draw the structures for the products in each of the reactions in the following sequence

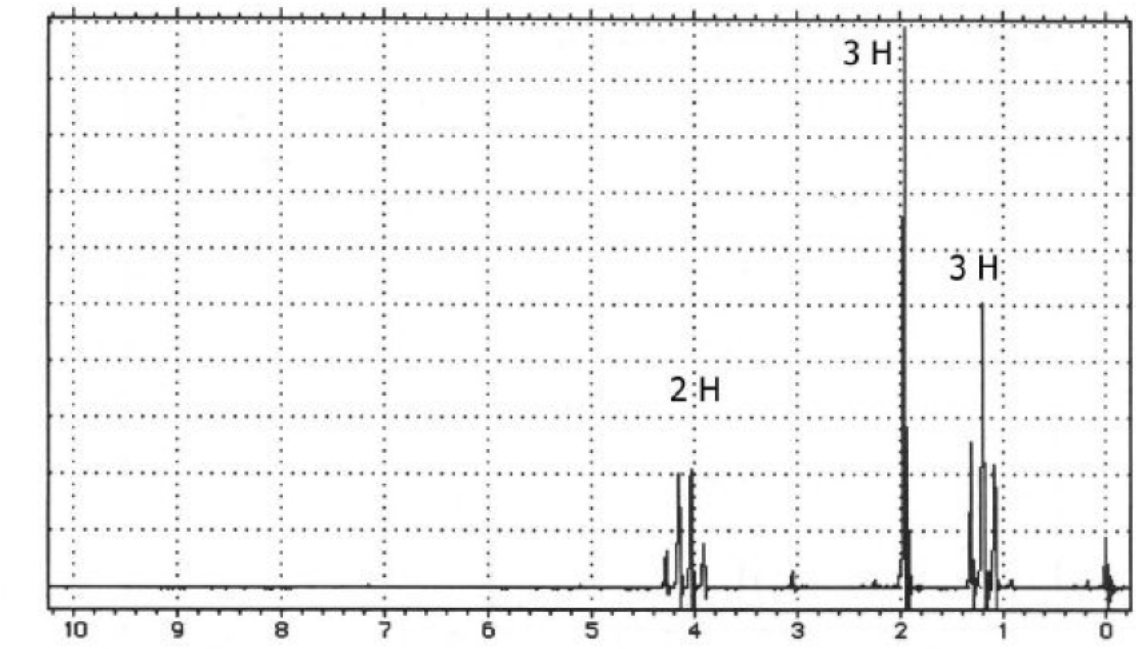


VI. Spectroscopy

Using this IR, NMR and molecular formula, draw the structure of the compound. You must provide: (i) the degree of unsaturation, (ii) analysis the IR spectra, (iii) analysis of NMR and (iv) accurate structure.

$C_4H_8O_2$





$C_4H_8O_2$

$$DoU = \frac{(4\times2)+2-8}{2} = 1$$

IR

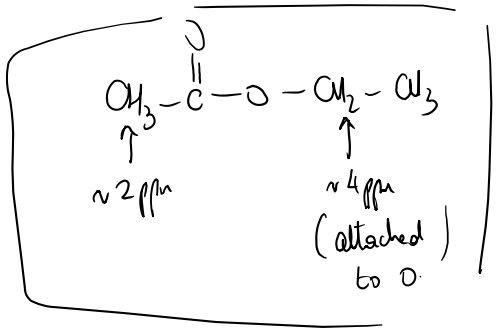
$< 3000\ cm^{-1} \Rightarrow C_{sp3}-H$

$\sim 1750\ cm^{-1} \Rightarrow C=O$

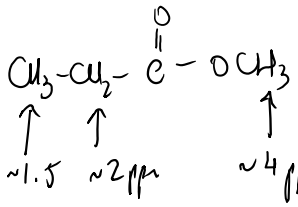
NMR

δ (ppm)	# H	multiplicity	observations
1.2	3H	t	CH_3 next to 2H
2.0	3H	s	CH_3 next to $\not$H
4.0	2H	q	CH_2 next to 3H

seeing each other

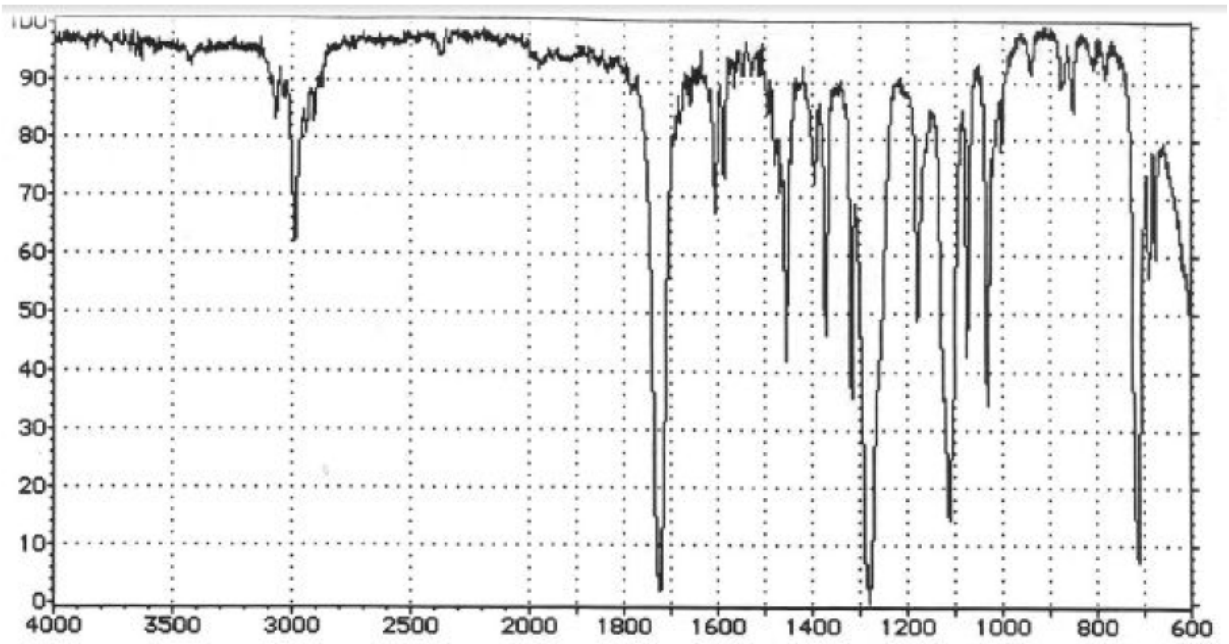


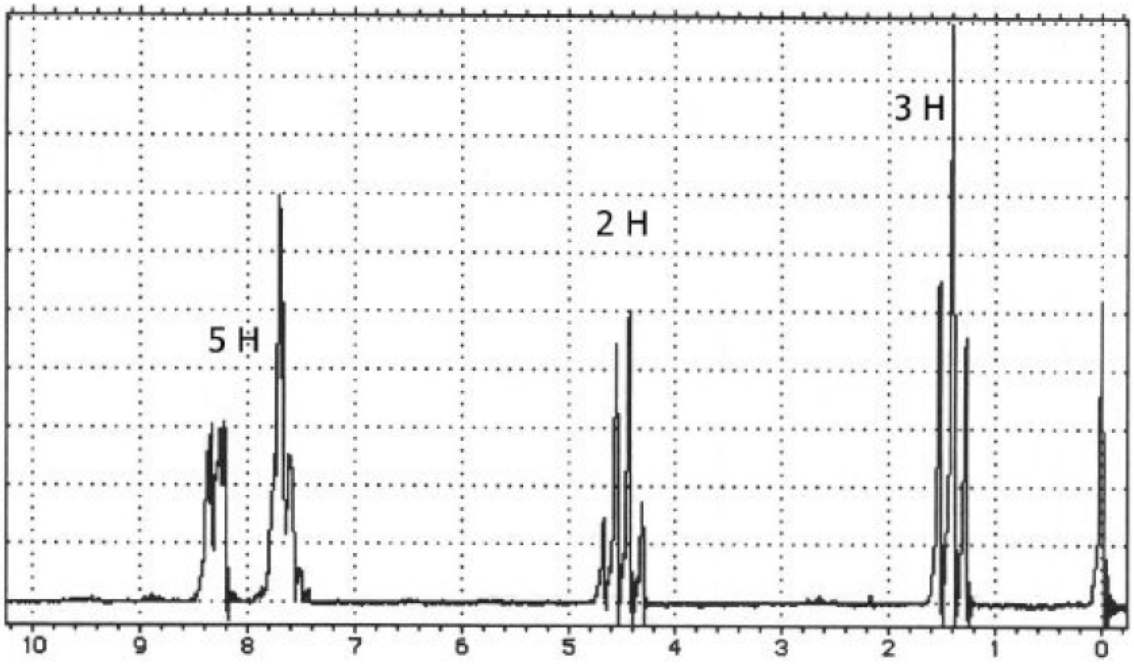
Vs



⇒ DOES NOT MATCHED THE DATA

$C_4H_{10}O_2$


90
80
70
60
50
40
30
20
10
0
4000
3500
3000
2500
2000
1800
1600
1400
1200
1000
800
600


3 H
2 H
5 H
10
9
8
7
6
5
4
3
2
1
0

$H_{10}O_2$ DoU $\frac{28 \quad +2-10}{2} = \emptyset$

IR =

$>< 3000\ cm^{-1} \Rightarrow C_{sp^3}-H + C_{sp^2}-H$

$\sim 1700\ cm^{-1} \Rightarrow C=O$

NMR

δ (ppm)	# H	multiplicity	interpretation
1.5	3	t	CH_3 ◁ 2H ↖ seeing each other
4.5	2	q	CH_2 ◁ 3H ↙ seeing each other
~8	5	N/A	⇒ mono substituted aromatic