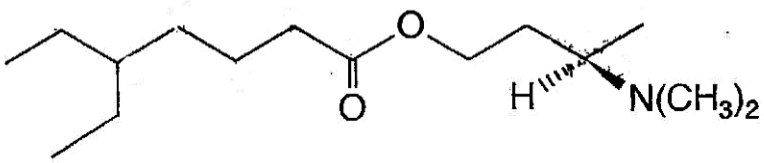
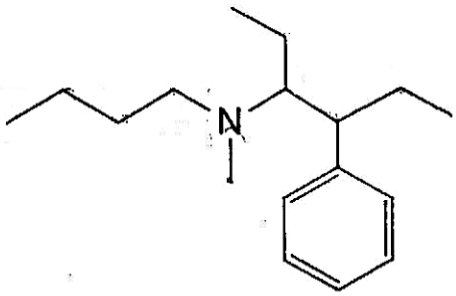
A. Nomenclature: (15 points)
Give an acceptable IUPAC name for each of the following compounds. Be sure to indicate the **stereochemistry** where appropriate.

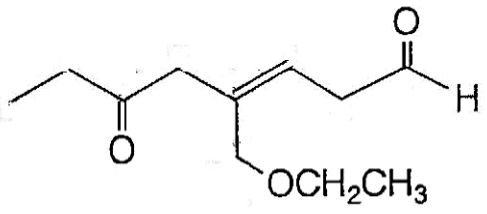
1.



2.

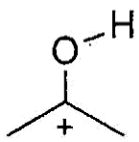


3.

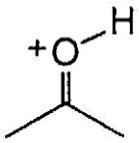


B. Facts: 8 points

1. Place the letter of the more stable resonance contributor in the box. (2 pts.)

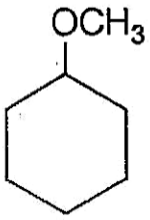


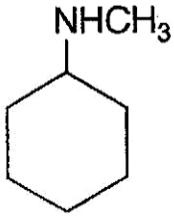
A

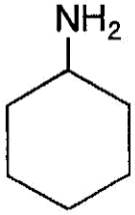


B

2. Rank the following compounds in order of increasing basicity. (1=least basic, 3=most basic) (6 pts.)

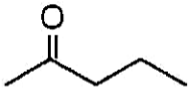






C. Reactions: Total = 32 points, 8 points each
Please provide the reagents or major product in the answer box. Be sure your drawing indicates **stereochemistry** if applicable. Partial credit is awarded only when intermediate products in a multi-step reaction are shown below the reaction.

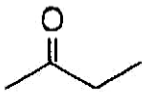
1.

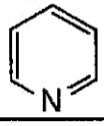
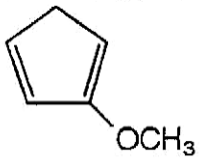
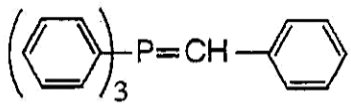


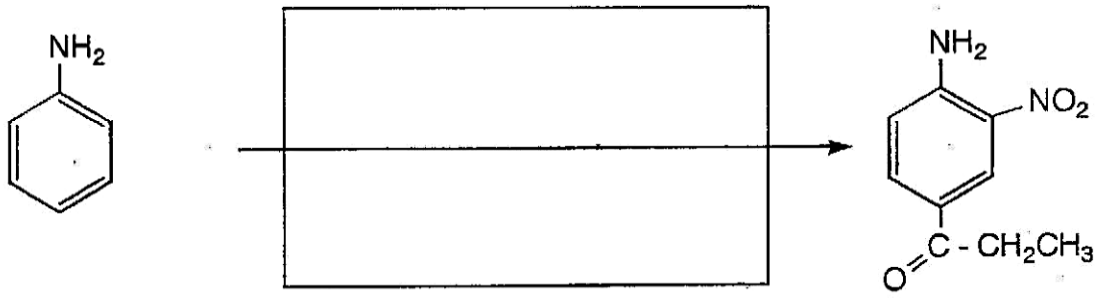
1. CH_3NH_2/ $NaBH_3CN$
2. CH_3I (XS)
3. Ag_2O / H_2O/ heat
4. MCPBA
5. CH_3O^- Na^+/ CH_3OH
6. H_3O^+

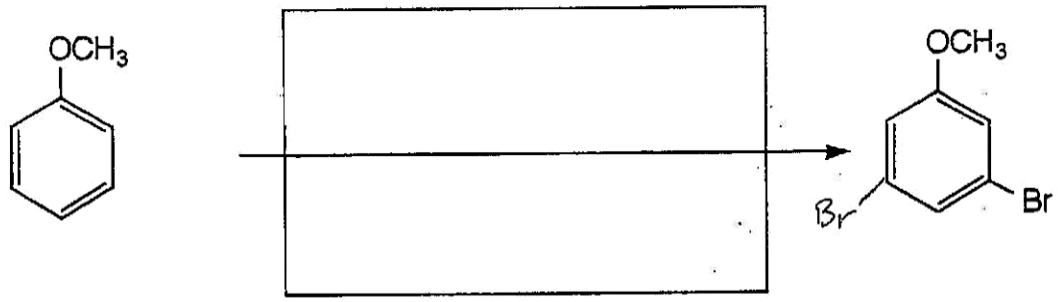
Note: MCPBA = m-chloroperbenzoic acid

2.



1. Br_2 / CH_3CO_2H
2.  or $(CH_3)_3CO^-Na^+$
3. 
4. 

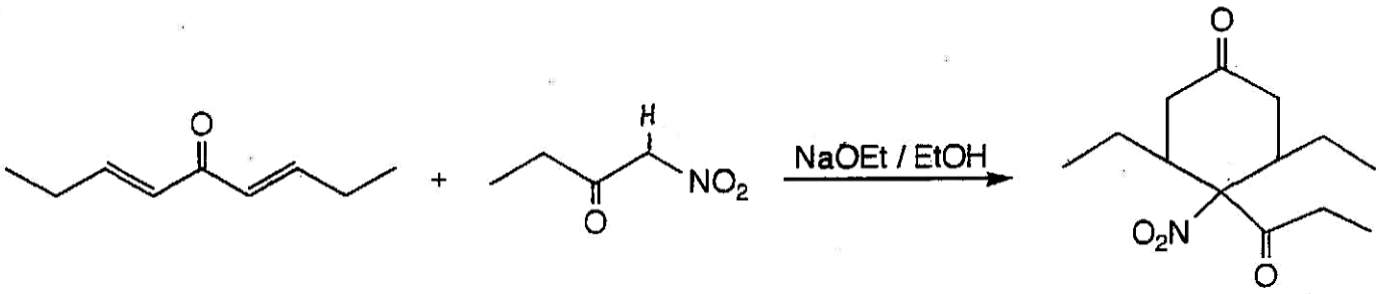
3. 

4. 

/13

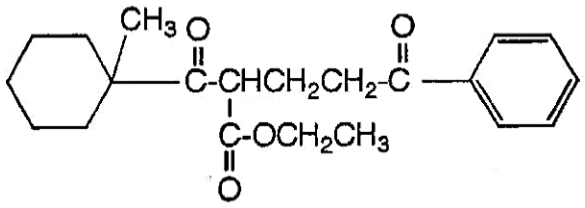
D. Mechanism: (15 points)

Provide a clear mechanism to explain the formation of the product. Use curved arrows to indicate "electron flow". Remember to show only one step at a time. **Show all intermediates and all formal charges. When more than one resonance contributor may be drawn, be sure to draw the most stable contributor.**



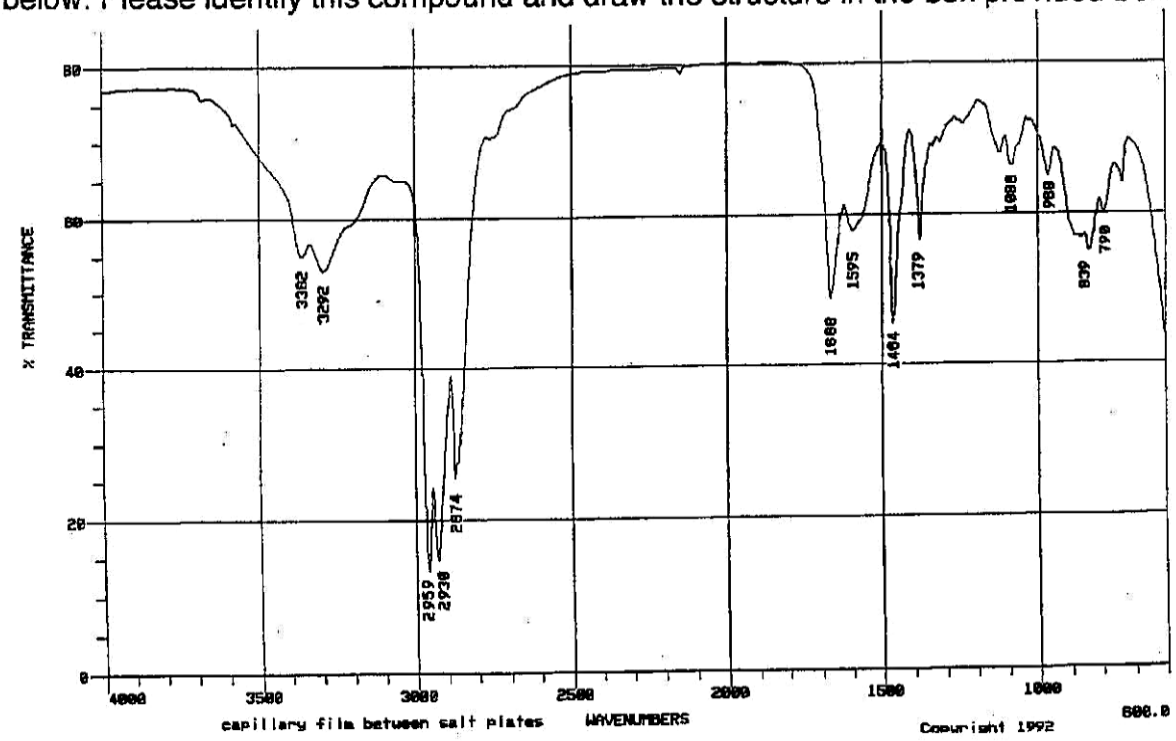
E. Synthesis: 15 Points

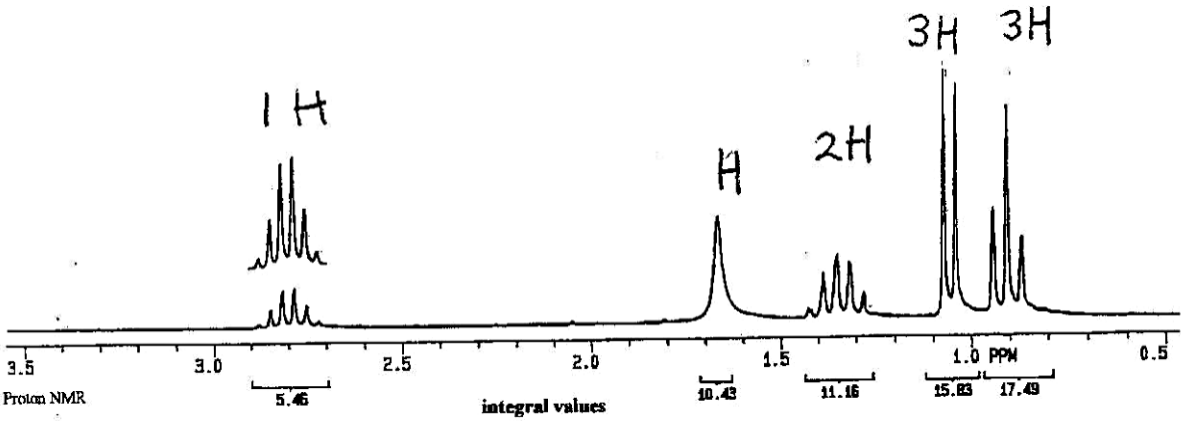
Synthesize the molecule below using any of the following reagents: benzene, cyclohexane, alcohols of **three carbons or less**, any inorganic reagents, any oxidizing or reducing agents, and any peroxyacids.



F. Spectroscopy: 15 Points

A compound with the formula $C_4H_{11}N$ exhibits the IR, ^1H NMR and proton decoupled ^{13}C NMR spectra shown below. Please identify this compound and draw the structure in the box provided below.





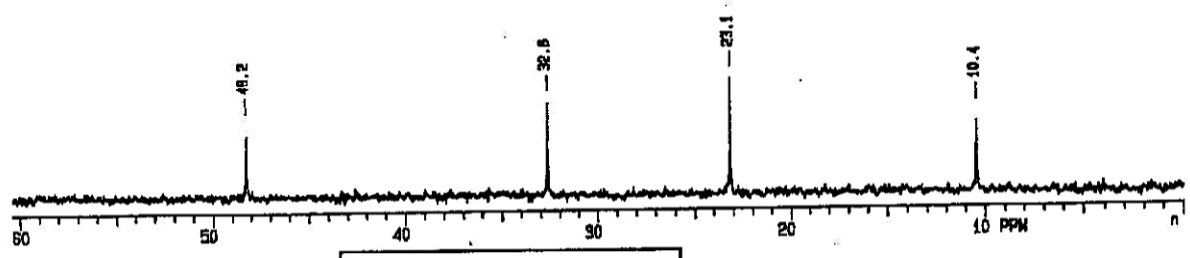


TABLE 13.3 Approximate proton chemical shifts

TYPE OF PROTON	CHEMICAL SHIFT (δ, ppm)
1° Alkyl, RCH_3	0.8–1.0
2° Alkyl, RCH_2R	1.2–1.4
3° Alkyl, R_3CH	1.4–1.7
Allylic, $R_2C{=}C(R){-}CH_3$	1.6–1.9
Ketone, $RC(=O)CH_3$	2.1–2.6
Benzylic, $ArCH_3$	2.2–2.5
Acetylenic, $RC{\equiv}CH$	2.5–3.1
Alkyl iodide, RCH_2I	3.1–3.3
Ether, $ROCH_2R$	3.3–3.9
Alcohol, $HOCH_2R$	3.3–4.0
Alkyl bromide, RCH_2Br	3.4–3.6
Alkyl chloride, RCH_2Cl	3.6–3.8
Vinylic, $R_2C{=}CH_2$	4.6–5.0
Vinylic, $R_2C{=}CH(R)$	5.2–5.7
Aromatic, ArH	6.0–9.5
Aldehyde, $RC(=O)H$	9.5–9.6
Alcohol hydroxyl, ROH	0.5–6.0[a]
Amino, $R{-}NH_2$	1.0–5.0[a]
Phenolic, ArOH	4.5–7.7[a]
Carboxylic, $RC(=O)OH$	10–13[a]

[a] The chemical shifts of these protons vary in different solvents and with temperature and concentration.

TABLE 13.4 Approximate carbon-13 chemical shifts

TYPE OF CARBON ATOM	CHEMICAL SHIFT (δ, ppm)
1° Alkyl, RCH_3	0–40
2° Alkyl, RCH_2R	10–50
3° Alkyl, $RCHR_2$	15–50
Alkyl halide or amine, $-\overset{\vert}{\underset{\vert}{C}}-X$ (X = Cl, Br, or $N\langle$)	10–65
Alcohol or ether, $-\overset{\vert}{\underset{\vert}{C}}-O$	50–90
Alkyne, $-C{\equiv}$	60–90
Alkene, $\rangle C{=}$	100–170
Aryl, $C_6H_5{-}C{-}$	100–170
Nitriles, $-C{\equiv}N$	120–130
Amides, $-C(=O)-N\langle$	150–180
Carboxylic acids, esters, $-C(=O)-O$	160–185
Aldehydes, ketones, $-C(=O)-$	182–215

GROUP	FREQUENCY RANGE (cm^{-1})	INTENSITY[a]
A. Alkyl		
C—H (stretching)	2853–2962	(m–s)
Isopropyl, $-CH(CH_3)_2$	1380–1385	(s)
and	1365–1370	(s)
tert-Butyl, $-C(CH_3)_3$	1385–1395	(m)
and	~1365	(s)
B. Alkenyl		
C—H (stretching)	3010–3095	(m)
C=C (stretching)	1620–1680	(v)
$R{-}CH{=}CH_2$ (out-of-plane C—H bendings)	985–1000	(s)
and	905–920	(s)
$R_2C{=}CH_2$ (out-of-plane C—H bendings)	880–900	(s)
cis-RCH=CHR (out-of-plane C—H bendings)	675–730	(s)
trans-RCH=CHR (out-of-plane C—H bendings)	960–975	(s)
C. Alkynyl		
≡C—H (stretching)	~3300	(s)
C≡C (stretching)	2100–2260	(v)
D. Aromatic		
Ar—H (stretching)	~3030	(v)
Aromatic substitution type (C—H out-of-plane bendings)		
Monosubstituted	690–710	(very s)
and	730–770	(very s)
o Disubstituted	735–770	(s)
m Disubstituted	680–725	(s)
and	750–810	(very s)
p Disubstituted	800–840	(very s)
E. Alcohols, Phenols, and Carboxylic Acids		
O—H (stretching)		
Alcohols, phenols (dilute solutions)	3590–3650	(sharp, v)
Alcohols, phenols (hydrogen bonded)	3200–3550	(broad, s)
Carboxylic acids (hydrogen bonded)	2500–3000	(broad, v)
F. Aldehydes, Ketones, Esters, and Carboxylic Acids		
C=O (stretching)	1630–1780	(s)
Aldehydes	1690–1740	(s)
Ketones	1680–1750	(s)
Esters	1735–1750	(s)
Carboxylic acids	1710–1780	(s)
Amides	1630–1690	(s)
G. Amines		
N—H	3300–3500	(m)
H. Nitriles		
C≡N	2220–2260	(m)

[a] Abbreviations: s = strong, m = medium, w = weak, v = variable, ~ = approximately.