CHM 2120
Midterm #2
November 10, 2010

Answers
Version A

First Name: _____ Last Name: _____

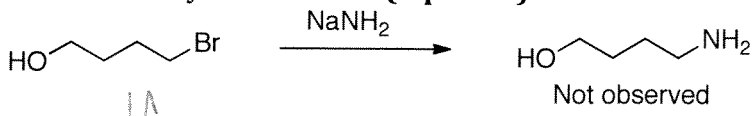
Student Number: _____

Seat number: _____

Approximate total number of marks:
The marks are given as a guide and are subject to minor changes.
You can write in pen or in pencil.
The use of molecular models is permitted but they cannot be shared.
The use of faculty-approved calculators and rulers are permitted but cannot be shared.

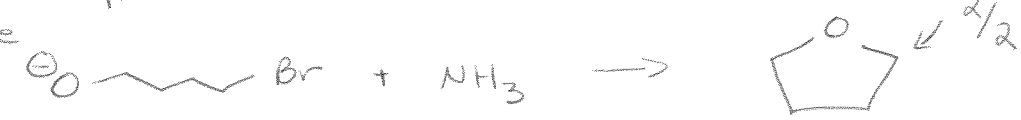
1a	2a	3b	4b	5b	6b	7b	8		1b	2b	3a	4a	5a	6a	7a	0
1 H																2 He
3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Ha	106 106												

1. The following reaction would not work as shown. Draw the product that would actually be obtained. **(2 points)**



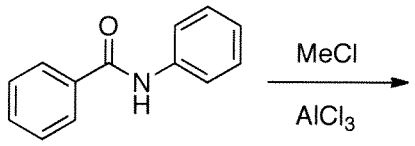
1/2

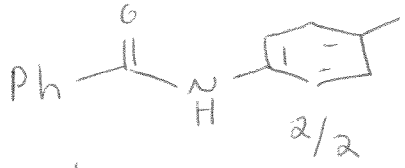
if only this one 1/2 →



2. Give the major product(s) for each of the following reactions:

a. **(2 points)**



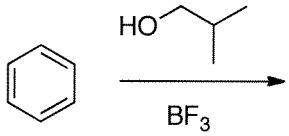


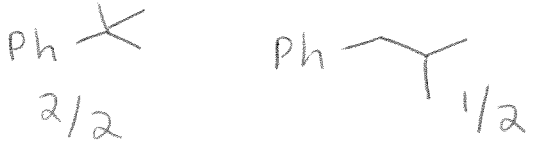
(+ ortho)

1/2 ortho only

another monosubstituted 0/2

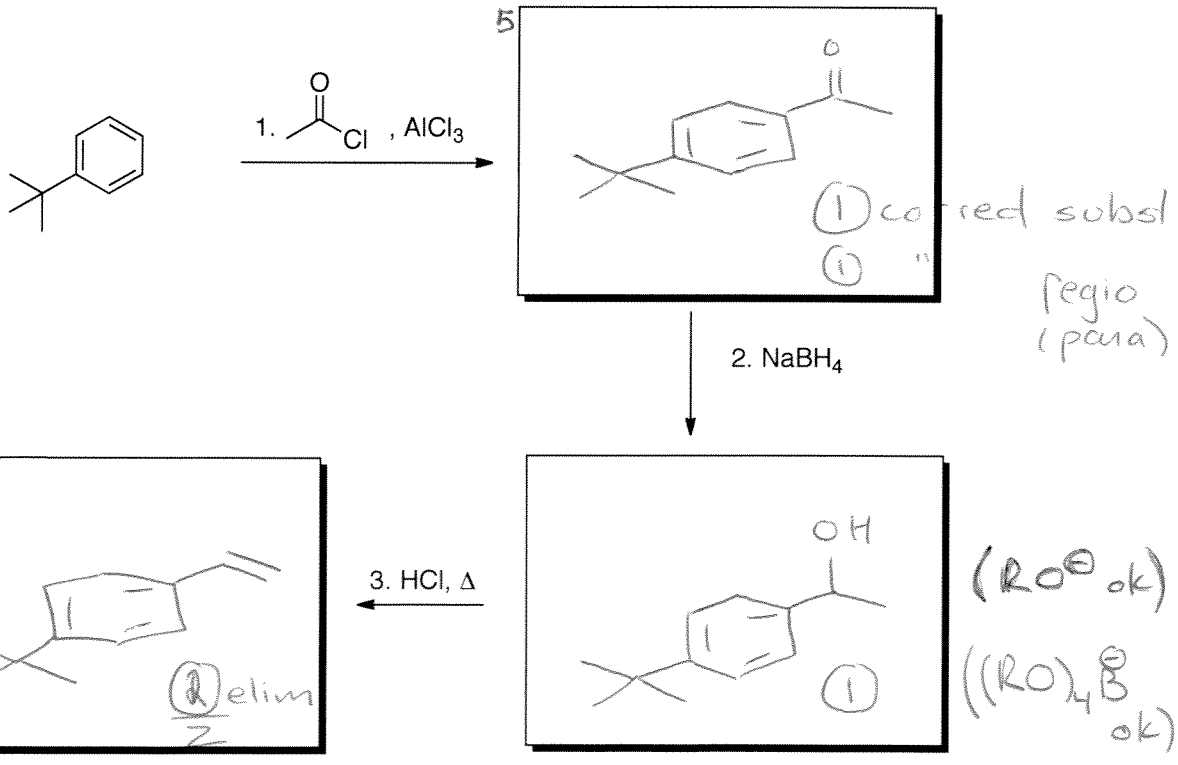
b. **(2 points)**





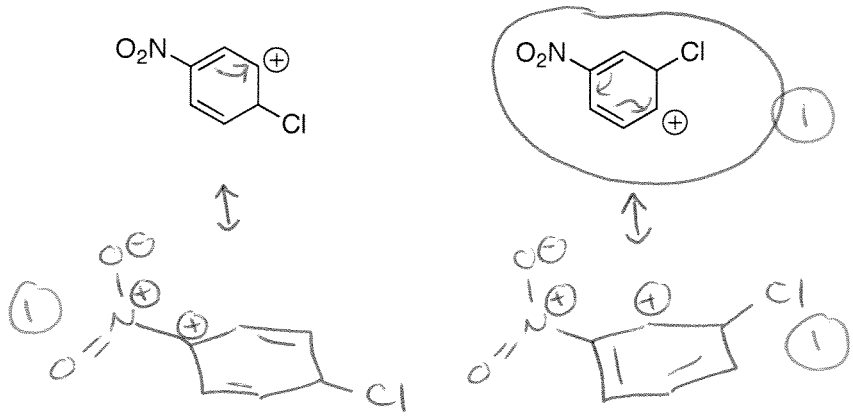
both: 1/2

3. Give the major product after each reaction. **(3 points)**



4.

a. Circle the most stable cation of the pair. **(1 point)**
b. Clearly justify your answer and include the key structures that support your answer. **(4 points)**



(1) 2 adjacent ⊕'s is very unstable

↑ never 2 adjacent (1) ⊕'s → more stable

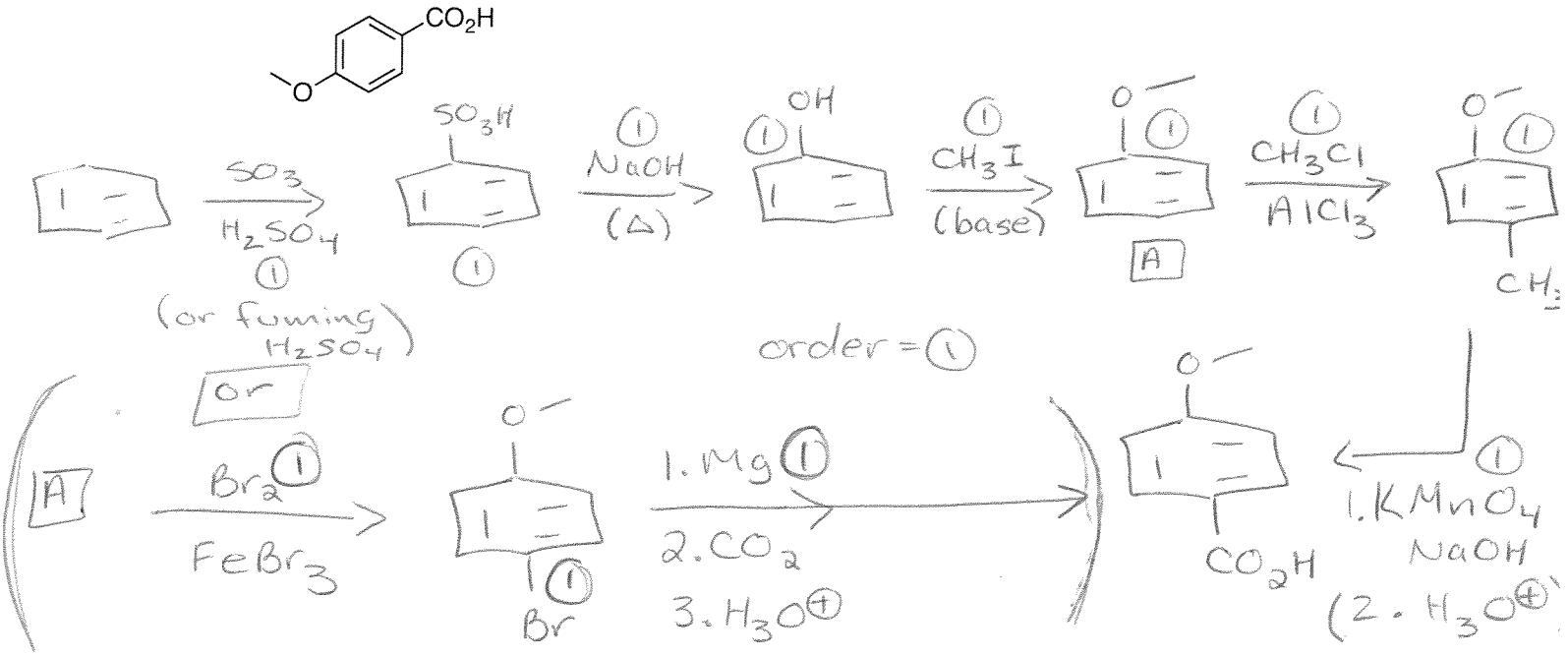
c. What is the type of intermediate shown in this question? **(1 point)**

arenium

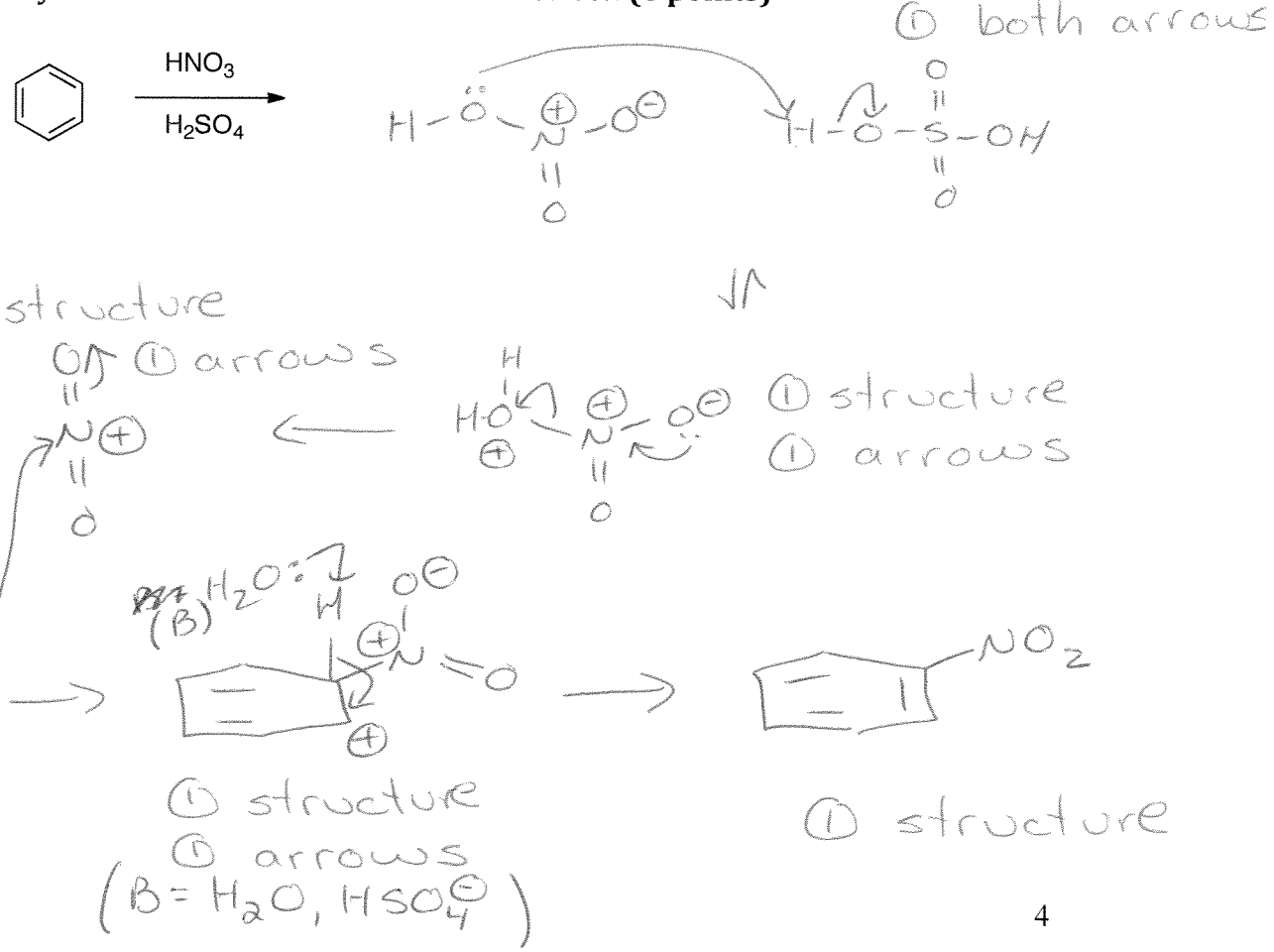
d. Name the final product that is produced when the circled cation reacts with a base. **(2 points)**

m-chloronitrobenzene
or
1-chloro-3-nitrobenzene

5. Propose a synthesis of the following compound from benzene. **(10 points)**



6. Draw the mechanism for the following reaction. It is not necessary to draw any resonance structures of the intermediate. **(8 points)**



7. Consider the following reaction coordinate diagram, in which **A** is the starting material. **(4 points)**

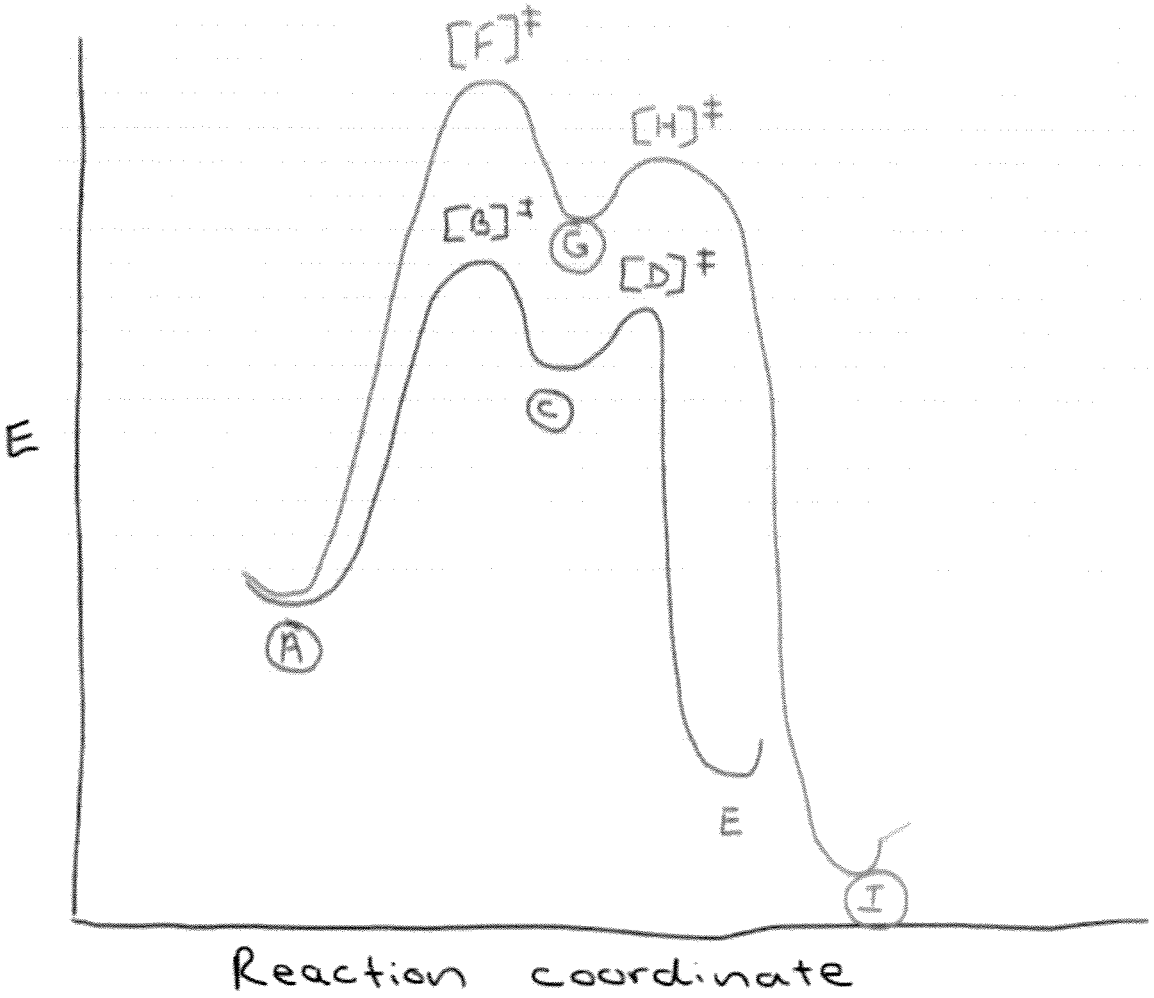
   a. What is the most stable final product? I (1)

   b. Which final product forms the fastest? E (1)

   c. Which structure does [B] most closely resemble? C (1)

   d. In one sentence, explain your answer in part c.

[B]‡ resembles the species to which it is closest in energy. (1)

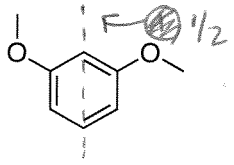


8. How would you distinguish between the following isomers by proton NMR? **(2 points)** (or $CH_2 \sim 2.2$ vs $CH_3 \sim 2.2$ α to C=O)

CH_3 between 3 and 5. (1)

(1) CH_2 between 3 and 5 - (the only signal in this region)

9. How many ^1H NMR signals would be observed in the following compound? **(2 points)**



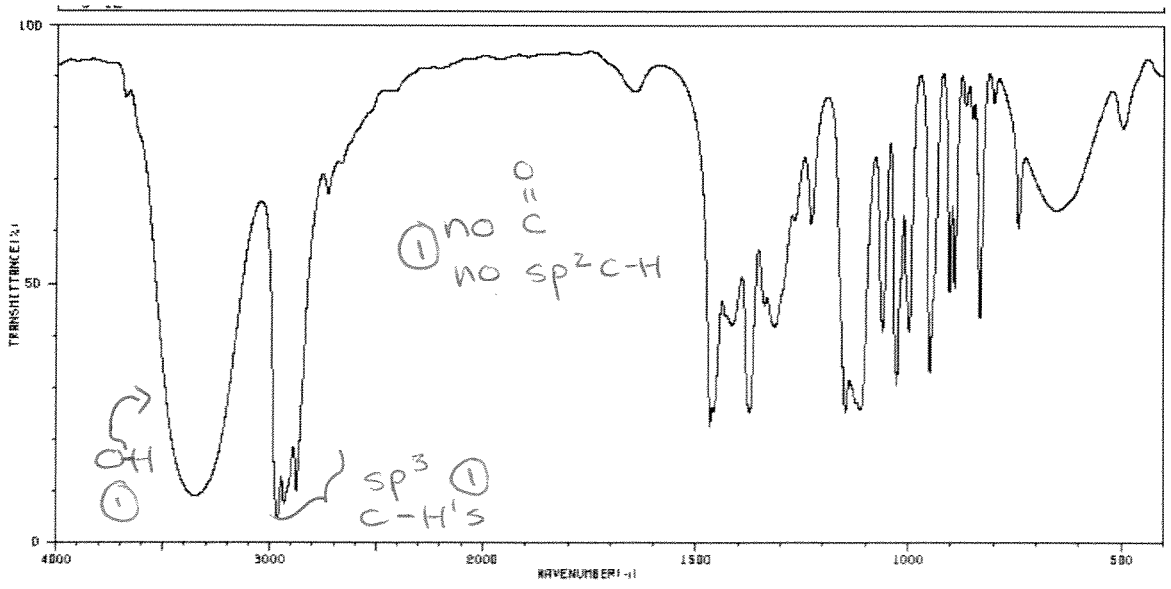
1/2

4

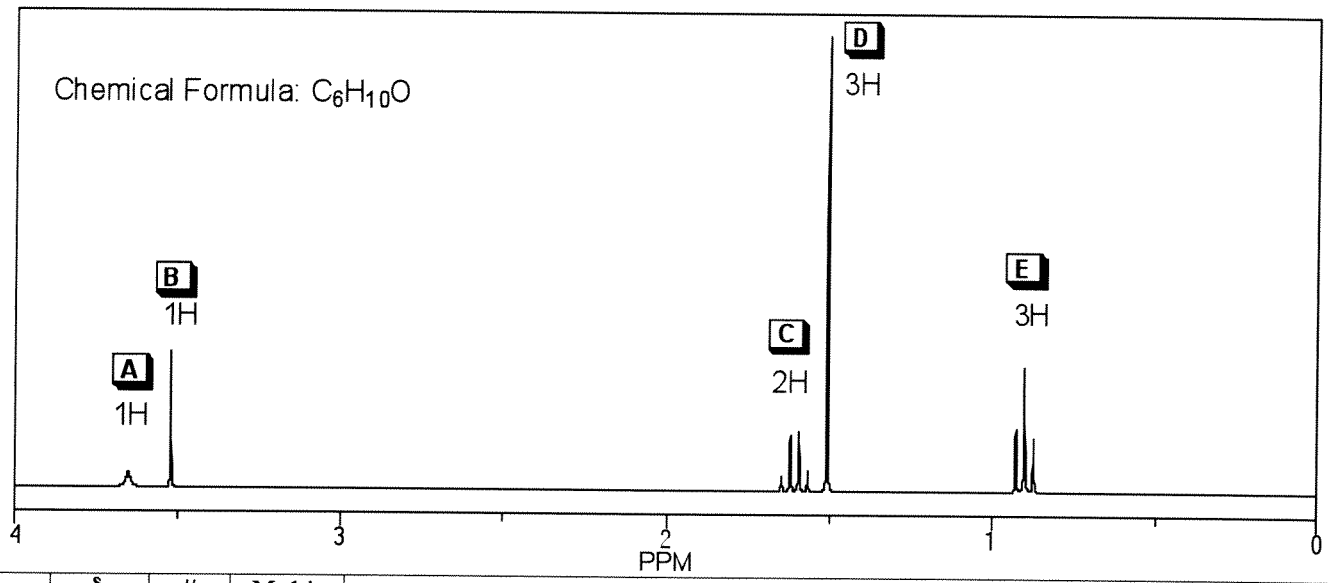
(1) 1/2

10. **(4 points)**
    a. Identify the key functional groups in the following IR spectrum.
    b. Circle the compound that corresponds to the following IR spectrum.

- Propanoic acid
- Benzyl alcohol
- 2-Pentanol (1)
- 1-phenylpropan-1-one



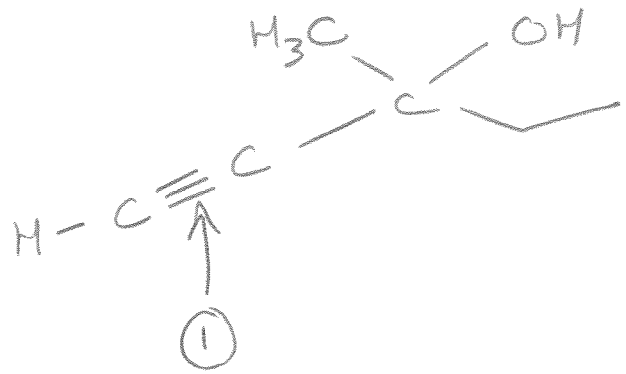
11. What is the structure of the unknown compound whose molecular formula is **$C_6H_{10}O$**? The ^1H NMR spectrum of this compound is below. **(9 points)**
The IR shows the following peaks: 3400 cm^{-1} (strong, broad), 3290 cm^{-1} (medium, sharp), ~2940 cm^{-1} (multiple peaks, medium, sharp), and 2219 cm^{-1} (medium, sharp).



Signal	δ (ppm)	# H's	Multi-plicity	Comments/Ideas
A	~3.6	1H	(br) s	n=0 + OH (1)
B	~3.5	1H	s	n=0 ≡CH (1) (CH on alkyne)
C	~1.6	2H	q	n=3 + CH_2CH_3 (1)
D	~1.5	3H	s	n=0 + CH_3 (1)
E	~0.9	3H	t	n=2 − CH_2CH_3
			(1)	(1)

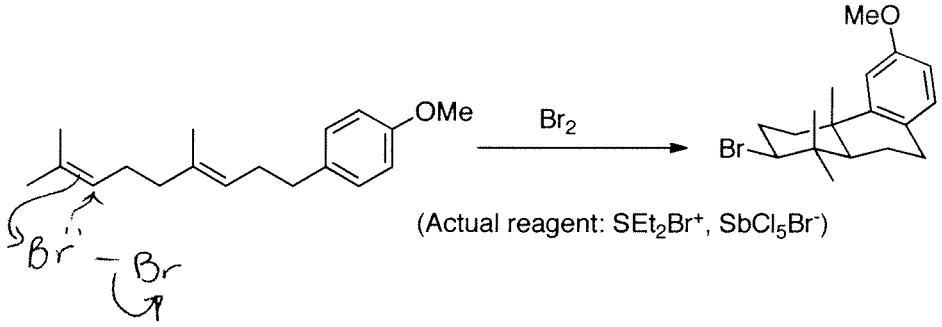
errors ignored in column of ideas

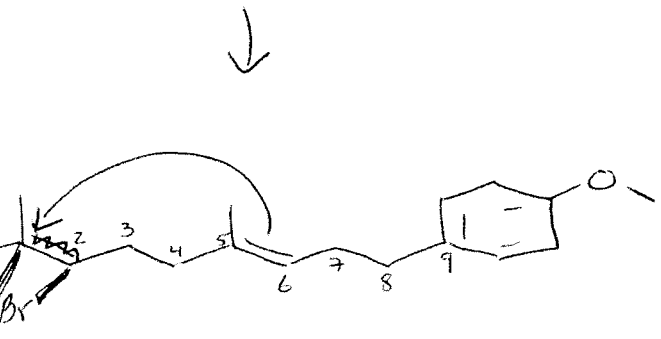
DU = 2



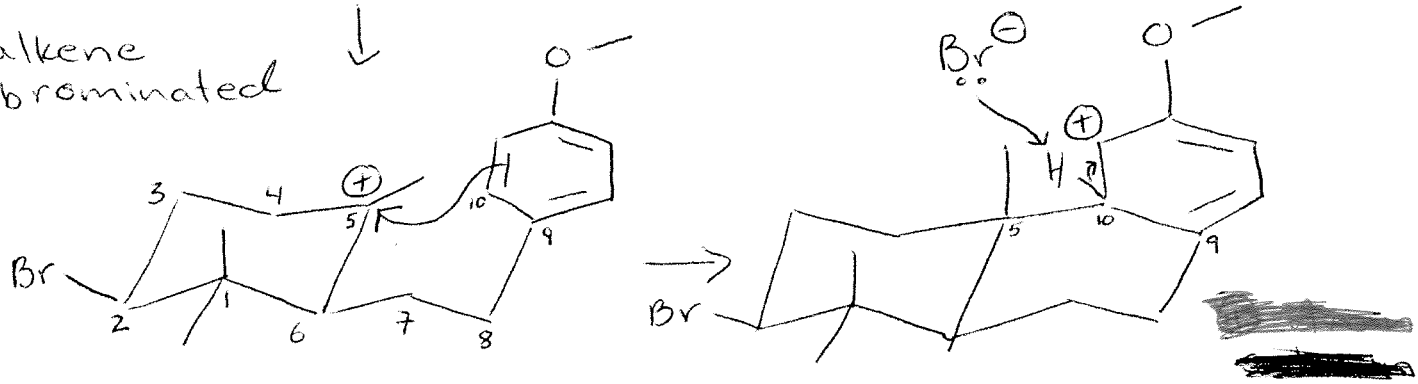
errors not ignored unless crossed out

BONUS! **(3 points)**
Provide a mechanism for the following transformation:

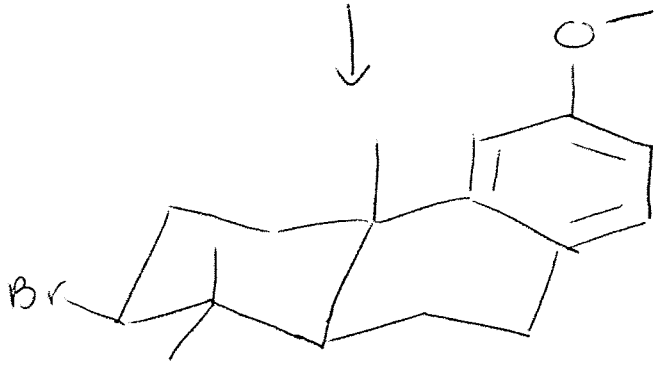




① alkene brominated



① cyclization



3/3 - perfect mechanism

IR: Key Absorptions (cm^{-1}):

C-H	Alkyl	C-H	2850-2960	m-s, sharp
C-H	sp^2	C-H	just >3000	m-s, sharp
Alcohol		**R-O-H**	3200-3650	s, broad
Carboxylic acid		R-C(=O)**O-H**	2500-3300	s, broad
Amine		R_2**N-H**	3300-3500	s, broad
Carbonyl		R_2**C=O**	1650-1780	s, sharp
Nitrile		R**C≡N**	2220-2260	v, sharp
Alkynyl		C≡**C-H**	~3300	m-s, sharp
Alkynyl		**C≡C**	2100-2260	v, sharp

^{1}H NMR – Key APPROXIMATE chemical shifts (ppm):