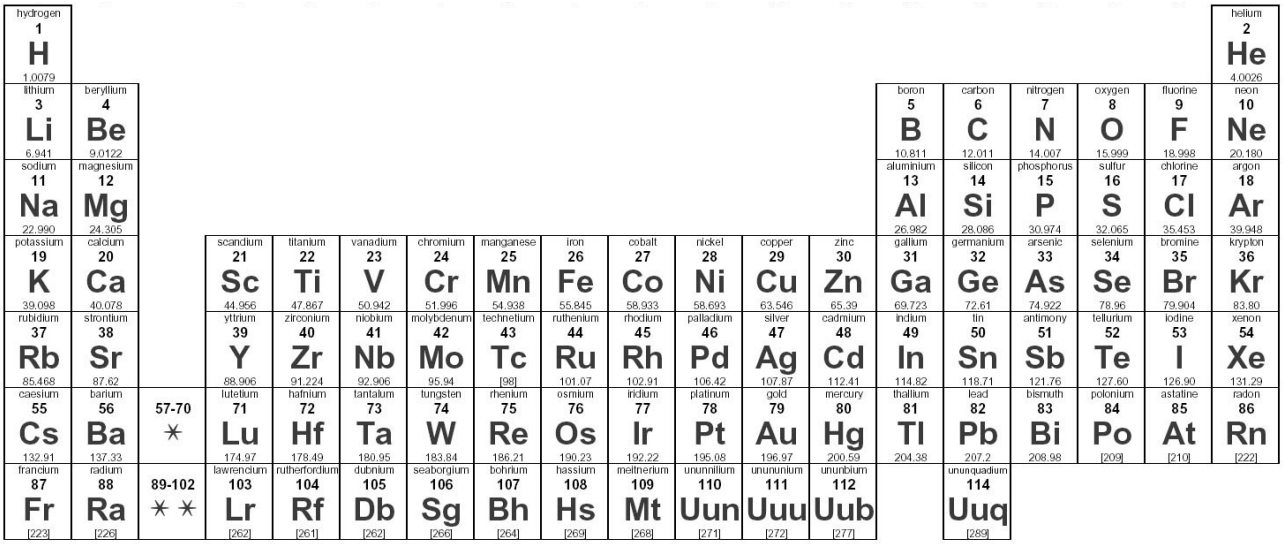
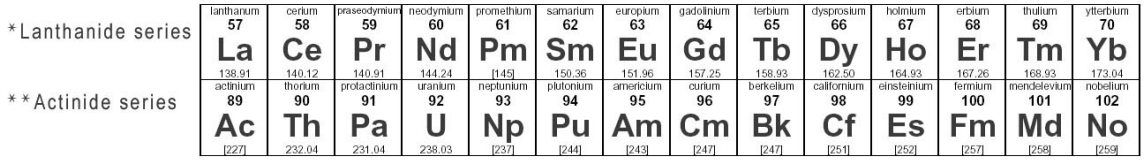
CH 336
Midterm Exam 1
Friday, April 22, 2016 Name_____

You may use a molecular model kit, but no other notes or material with chemical information. Electronic gadgets (including but not limited to: calculators, phones, MP3 players, smart watches) are prohibited; we may ask you to leave electronic watches at the front of the room or in your backpack for the exam period.

Please ask questions if a question is not clear.





Score Table:

Section I _____/20

Section II _____/25

Section III _____/20

Section IV _____/21

Srction V _____/14

Total: _____/100

Table 10-2 Typical Hydrogen Chemical Shifts in Organic Molecules

Type of hydrogen[a]	Chemical shift δ in ppm	
Primary alkyl, RCH_3	0.8–1.0	Alkane and alkane-like hydrogens
Secondary alkyl, RCH_2R'	1.2–1.4	
Tertiary alkyl, R_3CH	1.4–1.7	
Allylic (next to a double bond), $R_2C{=}C(CH_3)R'$	1.6–1.9	Hydrogens adjacent to unsaturated functional groups
Benzylic (next to a benzene ring), $ArCH_2R$	2.2–2.5	
Ketone, $RCCH_3$ (O)	2.1–2.6	
Alkyne, $RC{\equiv}CH$	1.7–3.1	
Chloroalkane, RCH_2Cl	3.6–3.8	Hydrogens adjacent to electronegative atoms
Bromoalkane, RCH_2Br	3.4–3.6	
Iodoalkane, RCH_2I	3.1–3.3	
Ether, RCH_2OR'	3.3–3.9	
Alcohol, RCH_2OH	3.3–4.0	
Terminal alkene, $R_2C{=}CH_2$	4.6–5.0	Alkene hydrogens
Internal alkene, $R_2C{=}CH(R')$	5.2–5.7	
Aromatic, ArH	6.0–9.5	
Aldehyde, RCH (O)	9.5–9.9	
Alcoholic hydroxy, ROH	0.5–5.0	(variable)
Thiol, RSH	0.5–5.0	(variable)
Amine, RNH_2	0.5–5.0	(variable)

[a] R, R′, alkyl groups; Ar, aromatic group (not argon).

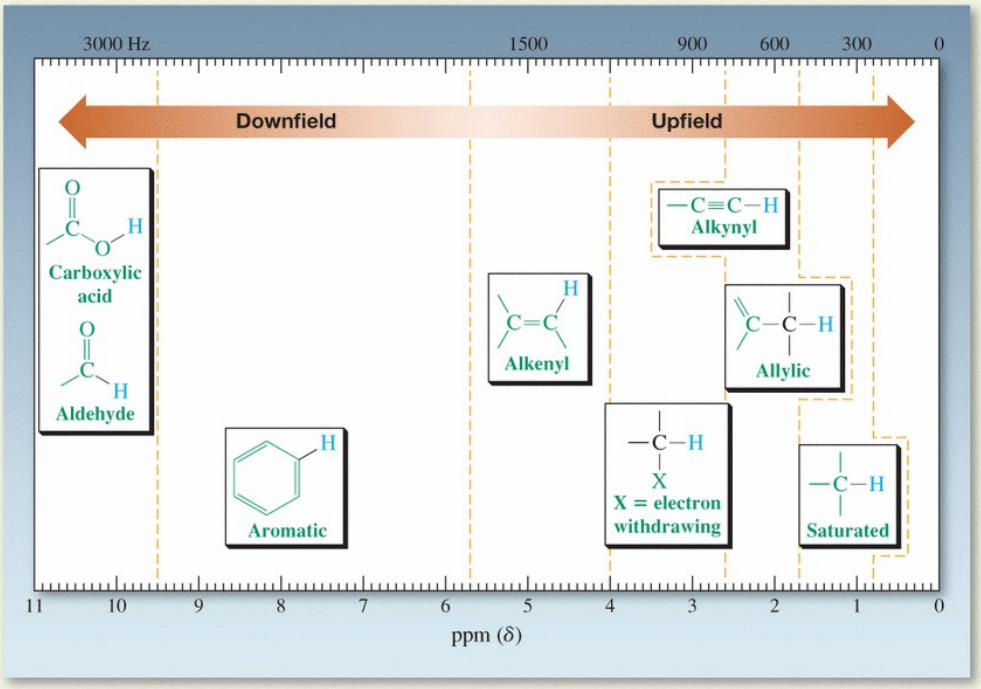
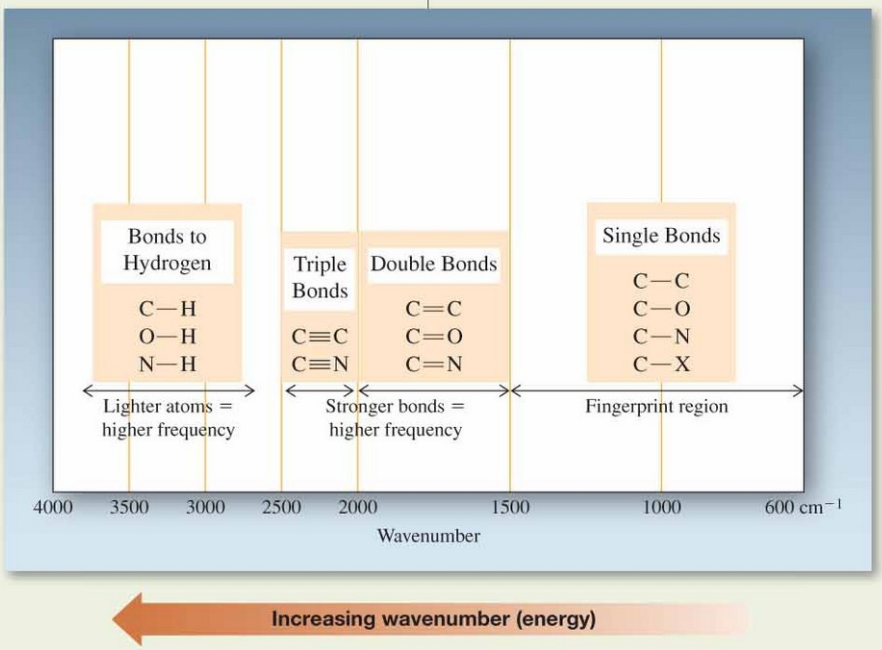


Table 11-4 Characteristic Infrared Stretching Wavenumber Ranges of Organic Molecules

Bond or Functional Group	$\tilde{\nu}$ (cm^{-1})	Bond or Functional Group	$\tilde{\nu}$ (cm^{-1})
RO—H (alcohols)	3200–3650	RC≡N (nitriles)	2220–2260
RCO—H (carboxylic acids)	2500–3300	RCH, RCR′ (aldehydes, ketones)	1690–1750
R_2N—H (amines)	3250–3500	RCOR′ (esters)	1735–1750
RC≡C—H (alkynes)	3260–3330	RCOH (carboxylic acids)	1710–1760
C=C (alkenes)	3050–3150	C=C (alkenes)	1620–1680
—C—H (alkanes)	2840–3000	RC—OR′ (alcohols, ethers)	1000–1260
RC≡CH (alkynes)	2100–2260		



Increasing wavenumber (energy)

Section I (4 points each) Select the best answer among the possibilities given and circle it.

1. How does the dipole moment 3-pentanone compare with that of diethyl ether?

a. 3-Pentanone > diethyl ether because the C=O double bond is more polarized.

b. Diethyl ether > 3-pentanone because there are 2 C-O bonds.

c. Both are equal, because each has a C-O bond.

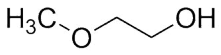
d. As neutral molecules, both lack a dipole moment.

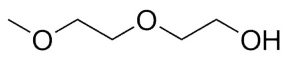
2. Select the structure that best matches the following spectroscopic data.

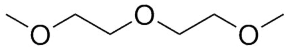
IR (cm^{-1}): 3200-3600, s, br; 2931 s; 2911 s; 2883 m; 2829 m; 1458 m; 1408 m; 1368 m; 1196 m; 1124 s; 1066 s; 1019 m; 891 m; 835 m.

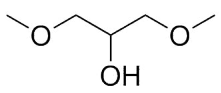
^{1}H NMR (ppm): 3.71 t, 2H, J = 7 Hz
3.52 t, 2H, J = 7 Hz
3.40 s, 3H
3.21 br s, 1H (disappears on shaking with D_2O)

^{13}C NMR (ppm): 74.21, 61.55, 58.91

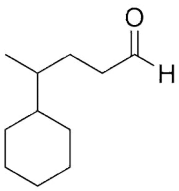
a. 

b. 

c. 

d. 

3. Select the best name for the following compound.



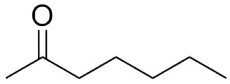
a. 4-phenylbutanal

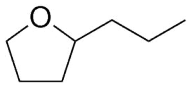
b. 4-cyclohexylbutyl ketone hydride

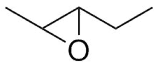
c. 4-cyclohexylbutanal

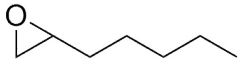
d. 4-cyclohexylbutanol

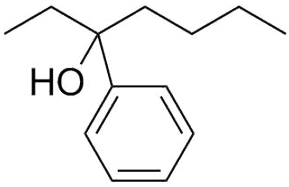
4. Select the structure whose name is both 2-pentyloxirane, or 1-heptene oxide.

a. 

b. 

c. 

d. 

5. The best set of reactants to form 3-phenyl-3-heptanol (shown) are 

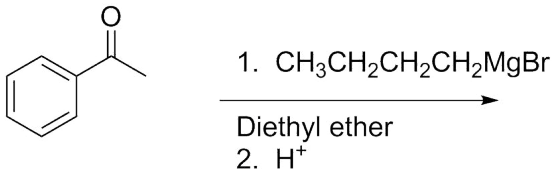
a. 3-heptanone plus $NaBH_4$ in one step, followed by H+.

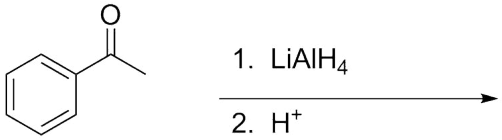
b. 3-heptanone plus C_6H_5MgBr in one step, followed by H^+.

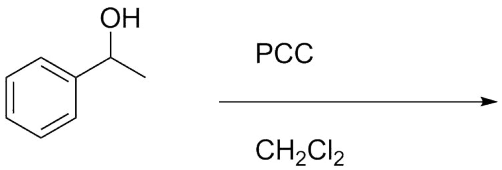
c. Benzoic acid plus one mole of ethylmagnesium bromide, then one mole of butylmagnesium bromide.

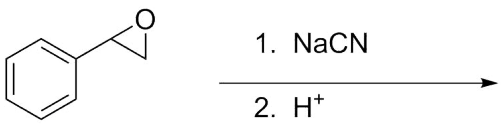
d. 3-phenylheptane plus Jones' reagent.

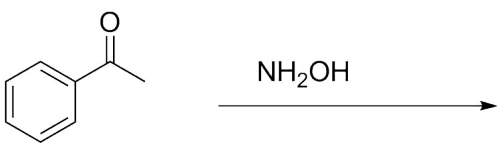
Section II. (5 points each) Draw the major organic product for each of the following reactions.

6. 

7. 

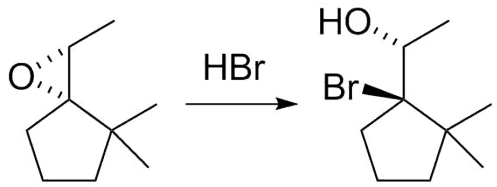
8. 

9. 

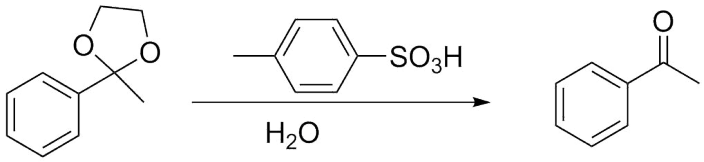
10. 

Section III. (10 points each) Write a mechanism for each of the following two transformations. Use electron-pushing arrows correctly, designate lone pairs where necessary, and make sure charges are correctly shown. If resonance is a stabilizing influence for any structure, show appropriate resonance forms.

11.



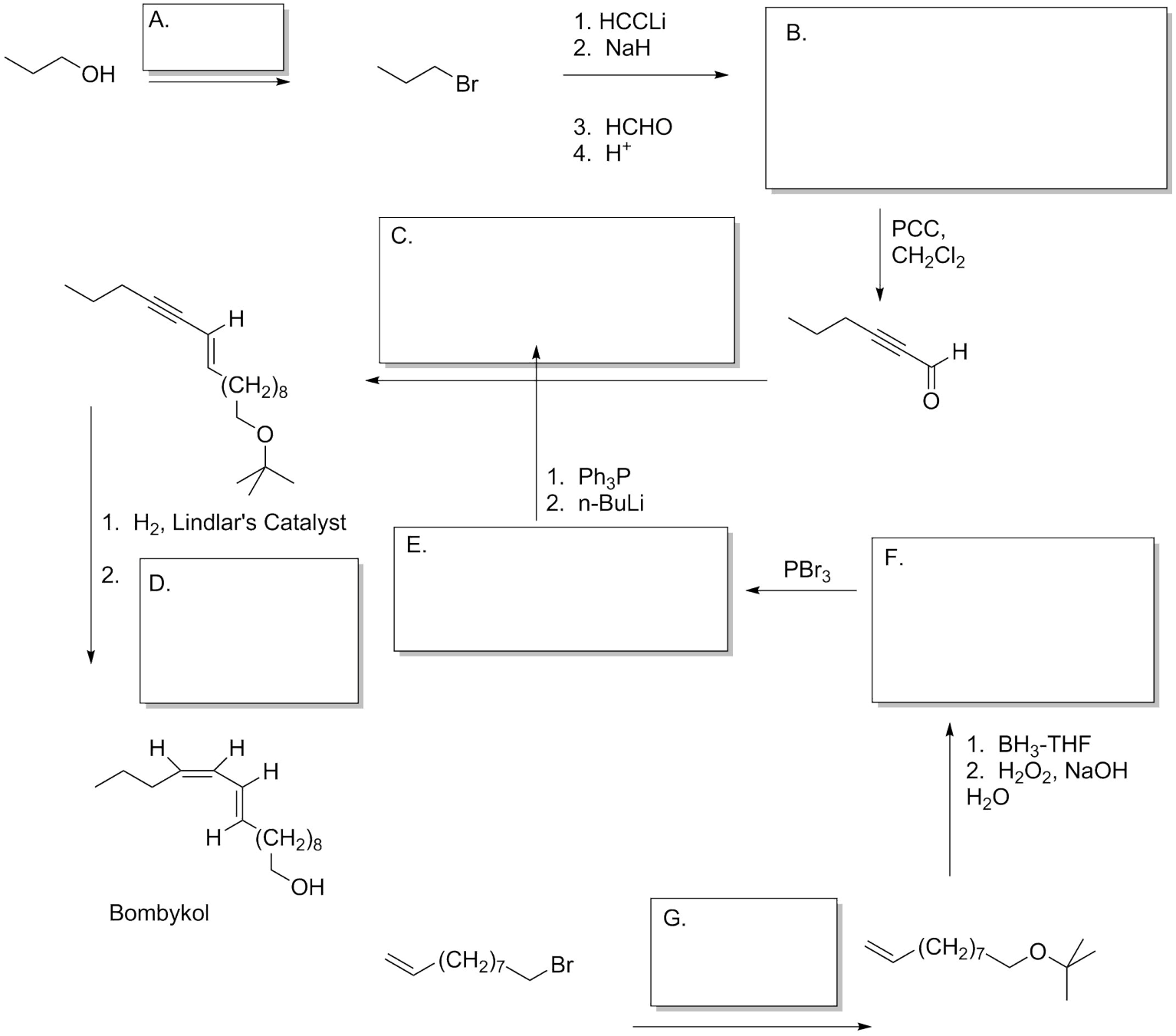
12.



Section IV. (21 points)

13. Fill in the boxes with the correct organic structure or set of reagents/conditions to complete the following multistep synthesis of bambykol, an insect hormone secreted by the silk moth.

Answers A, C, D, and G are all reagents; answers B, E and F are intermediate isolated compounds.



Section V.

14. (14 points) *trans*-2-Butene is epoxidized with mCPBA to a product **A** which then reacts with $LiCuMe_2$ (followed by acid workup) to give a new product **B** having an IR spectrum that has a strong, broad peak between 3300-3600 cm^{-1}. Reaction of **B** with Jones' reagent gives a new compound **C** that shows the 3 spectra displayed on the following page; the mass spectrum has important peaks at m/z = 86, 71, 43 and 41.

Draw structures for **A**, **B** and **C**. Explain the reaction chemistry and/or the spectral assignment to allow assignment of partial credit.

A =

B =

C =

Spectra for **C** (IR, ^{1}H NMR, ^{13}C NMR):