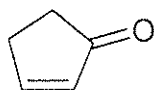
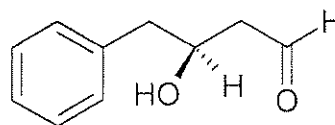


1. (12 pts, 3 each) Give the IUPAC name of the following compounds. Be sure to utilize E/Z or R/S prefixes when necessary.

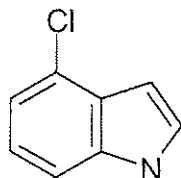
a)



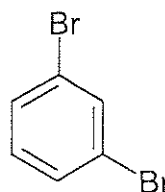
b)



c)

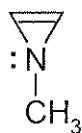


d)

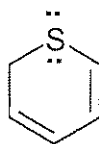


2. (6 pts, 2 each) Classify the following substances as either aromatic or nonaromatic.

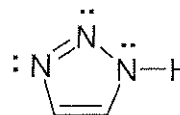
a)



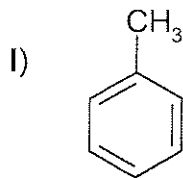
b)



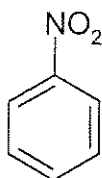
c)



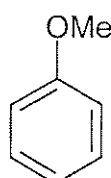
3. (4 pts) Rank the relative rate of bromination of the compounds below in an electrophilic aromatic substitution reaction (most activated ring to least activated ring).



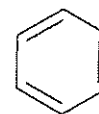
II)



III)



IV)



a) I > II > III > IV

b) III > IV > I > II

c) III > I > IV > II

d) I > III > IV > II

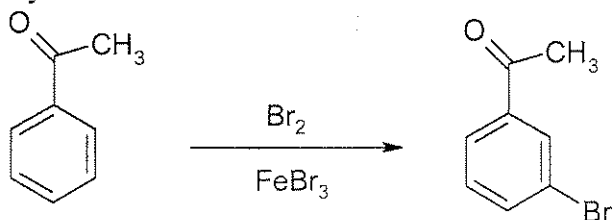
e) II > IV > I > III

4. (3 pts) In mass spectrometry, which statement best describes the molecular ion $[M]^+$ of a stable molecule?

- It is a carbocation with an even number of electrons.
- It is a radical anion.
- It is the most stable radical formed from the molecule.
- It is a radical cation.
- It is the most stable carbocation formed from the molecule.

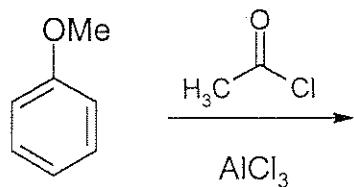
5. (12 pts) a) Explain why the major product formed in the following reaction is the META product and not the ortho and para products. BE SURE TO INCLUDE THE RESONANCE STRUCTURES OF THE INTERMEDIATE FORMED IN THE RXN AS PART OF YOUR EXPLANATION.

b) Explain why acetophenone (the starting material below) undergoes electrophilic aromatic substitution less readily than benzene itself.

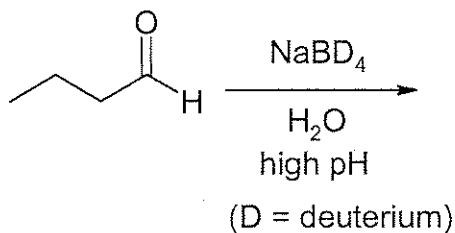


6. (16 pts, 4 each) Give the structures for the **major product** for the following transformations. If no reaction occurs, write **NO RXN**.

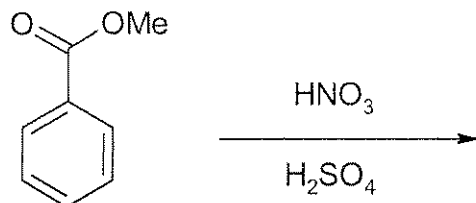
a)



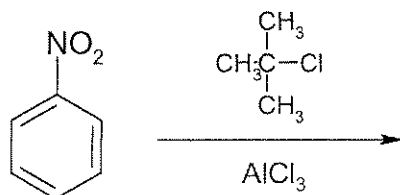
b)



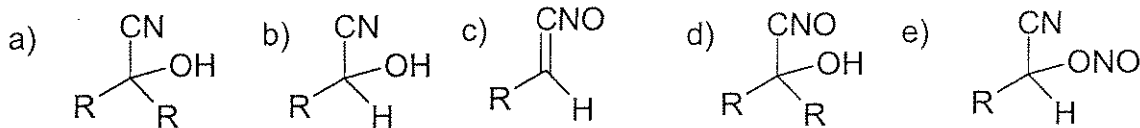
c)



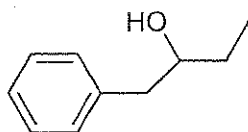
d)



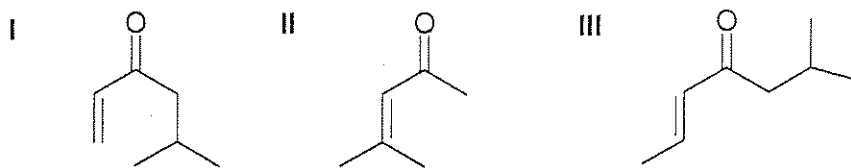
7. (3 pts) Which is the compound formed when an aldehyde reacts with NaCN followed by H_3O^+ ?



8. (7 pts) Suggest a synthesis for the following alcohol from an appropriate aldehyde or ketone and a Grignard reagent. (As part of your synthesis, please show how you would make the Grignard reagent from an appropriate starting material).

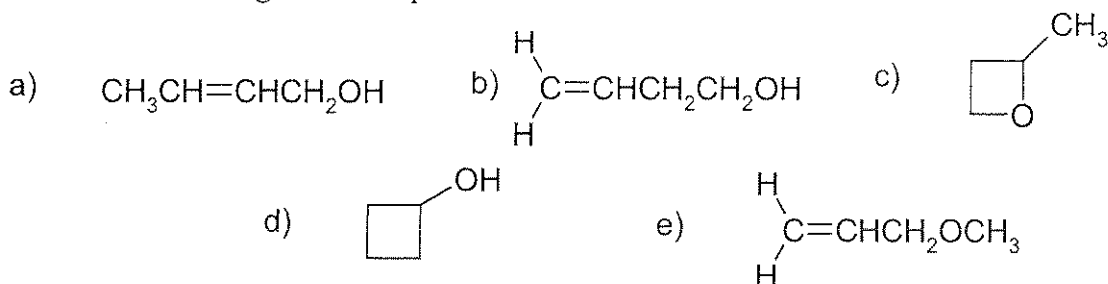


9. (3 pts) Rank the order of expected λ_{\max} for these substances in their UV-vis spectra.

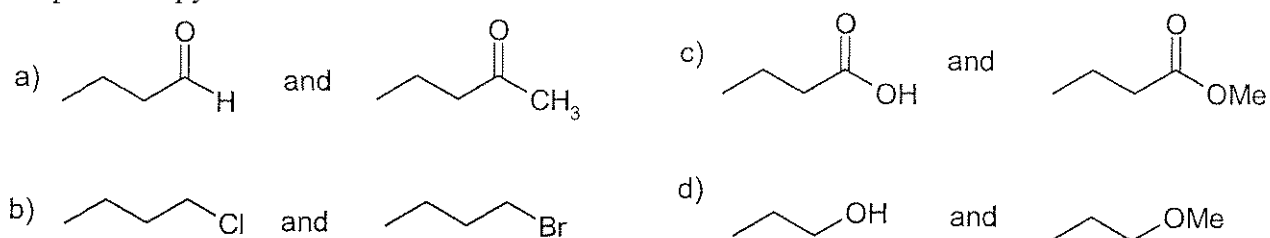


- a) longest λ_{\max} I > II > II shortest b) longest λ_{\max} II > III > I shortest
 c) longest λ_{\max} I > III > II shortest d) longest λ_{\max} II > I > III shortest
 e) longest λ_{\max} III > I > II shortest

10. (3 pts) The IR spectrum of a compound of formula C_4H_8O exhibits a strong, broad band at 3320 cm^{-1} , no bands between 3000 and 3300 cm^{-1} , nor any between 1600 and 1680 cm^{-1} . Which of the following is the compound?



11. (3 pts) Which pair of compounds could not be easily distinguished using infrared spectroscopy?



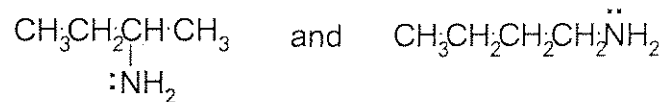
12. (1 pt) **True** or **False** $NaBH_4$ is a much stronger reducing agent than $LiAlH_4$ and consequently can be used to reduce aldehydes and ketones as well as esters and amides.

13. (3 pts) Ultraviolet-visible spectra of molecules typically consist of **broad** peaks (rather than sharper peaks as observed in NMR spectroscopy). The broadening observed with molecules is due to the fact that the

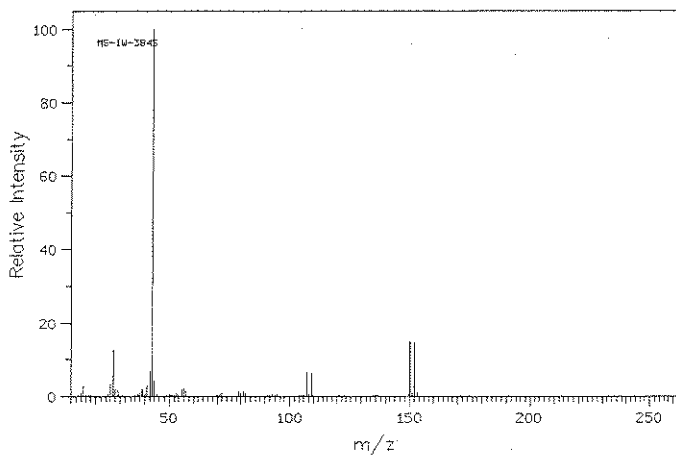
- atomic spectra for each atom within the molecule is observed, but the resolution of the instrument is not capable of isolating each.
- doppler effect causes a shift to both lower and higher wavelengths centered around the wavelength of maximum absorption.
- promotion of electrons from various vibrational states of bonding molecular orbitals to various vibrational states of the antibonding molecular orbitals occur, but the resolution is not capable of isolating each.
- electronic transitions for a given molecule can vary depending on the wavelength of electromagnetic radiation used to promote ground state electrons.

14. (10 pts) Due to high humidity in a chemical storage room over the summer, the labels on the containers of two primary amines fell off. It was known that the amines were the two compounds shown below, but it was not known which one was which. Mass spectra of both compounds were taken and it was found that compound A had a large peak at $m/z = 30$, while compound B had two larger peaks with $m/z = 44$ and $m/z = 58$.

a) Identify which amine is compound A and which is compound B, and b) using curved arrows, show the fragmentation pathway for each amine that gives rise to the peaks described above.



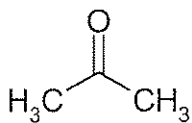
15. (8 pts) For the following mass spectrum of an organic unknown where the molecular ion is $m/z = 150.0$



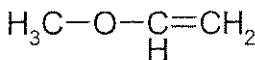
m/z	relative peak intensity
150.0	14.7
151.0	0.7
152.0	14.4

a) Determine a possible molecular formula for this compound. Please **SHOW YOUR WORK**.

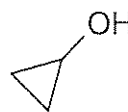
16. (6 pts) Briefly explain how one could differentiate the three isomers A, B and C of molecular formula C_3H_6O shown below by infrared spectroscopy.



A



B



C