# Second Exam
# CHEM 256 – Organic Chemistry II
# Prof. Bastin
# Spring 2016

**Name _____ Section _____**

1. DO NOT START this exam until you are instructed to begin.
2. There are ELEVEN pages including this cover sheet and the IR frequency table - make sure they are all here!
3. Provide *CLEAR, CONCISE* answers using unambiquous, carefully drawn structures and mechanisms for the appropriate questions. *Be sure to read each question VERY CAREFULLY*.
4. Do not provide mechanisms for synthesis and product prediction problems.
5. You may only use a pen or pencil and the materials provided in this packet on this exam.
6. If you have papers and/or books with you, they are to be left on the floor **AT THE FRONT OF THE ROOM**. If you need scrap paper please ask.
7. Cell phones must be **OFF and placed on the table at the FRONT of the ROOM**.

**1) _____/12 pts**

**2) _____/12 pts**

**3) _____/10 pts**

**4) _____/12 pts** **Total: _____/100 pts**

**5) _____/8 pts**

**6) _____/10 pts**

**7) _____/12 pts**

**8) _____/24 pts**

1) (12 pts) Provide structures for the following compounds.

a) *o*-bromobenzaldehyde

b) *p*-diaminobenzene

c) *o*-methylphenol

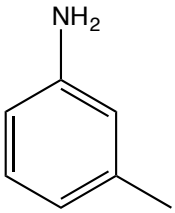
d) *m*-xylene

e) 2-hydroxy-3-bromo-5-butylbenzoic acid

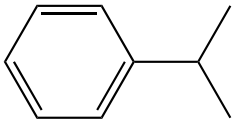
f) 3-chloroaniline

2) (12 pts) Provide either common or IUPAC names for the following compounds.

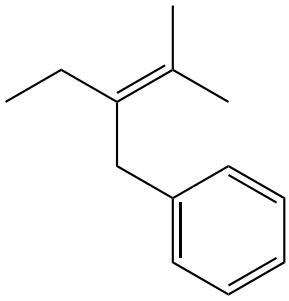
a)



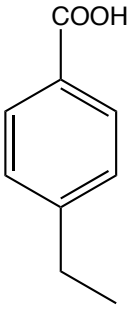

b)



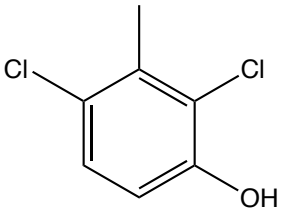
c)



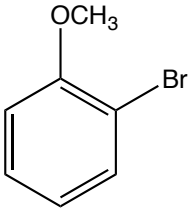
d)



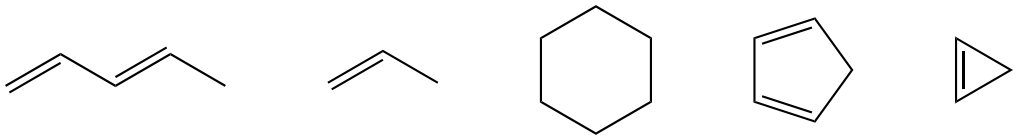

e)




f)



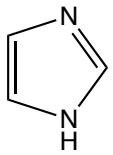
3) (10 pts) Rank the following compounds in order of decreasing acid strength, from lowest $pK_a$ to highest $pK_a$ (be sure your order is clearly indicated). Explain.

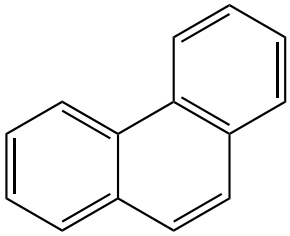


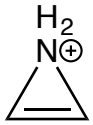
**A** **B** **C** **D** **E**

4) (12 pts) Predict whether each of the following molecules would be aromatic, non-aromatic, or anti-aromatic. Explain your reasoning.

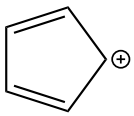
(a) (b) (c) (d)



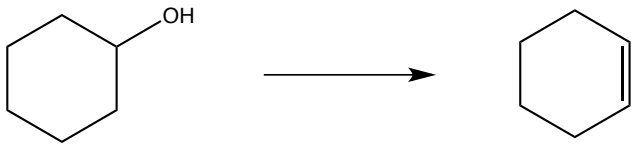



5) (8 pts) Using a Frost circle, draw the π MO energy diagram for the molecule below. Fill the orbitals with the appropriate number of π elections. Based on this diagram, should the molecule be aromatic, non-aromatic, or anti-aromatic? Explain.

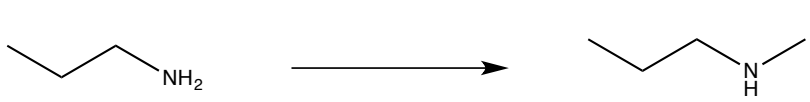


6) (10 pts) What differences in the IR spectra of the reactant and product in each of the following transformations would enable you to tell that each reaction took place? Be specific and give numbers. Include all distinguishing peaks.

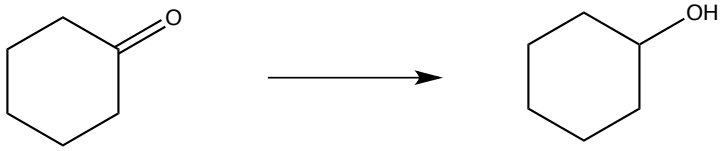
(a)




(b)

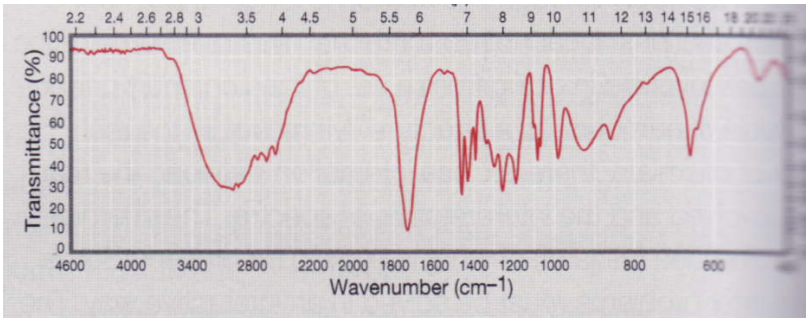



(c)

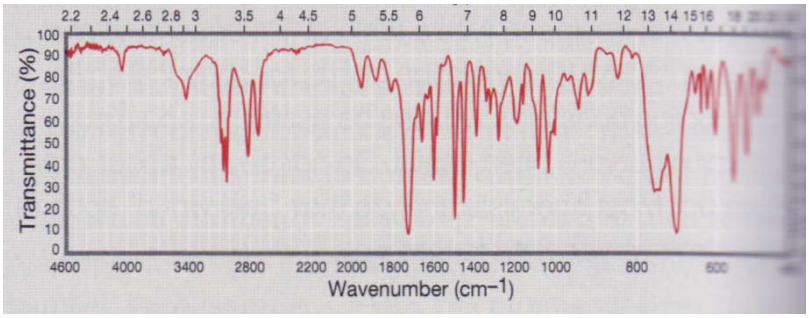


7) (12 pts) For each of the following IR spectra (**a-d**) there is a choice of three possible types of compounds. For each spectrum, choose the most appropriate class of compound. Explain your reasoning by noting the presence or absence of characteristic bands in the spectrum.

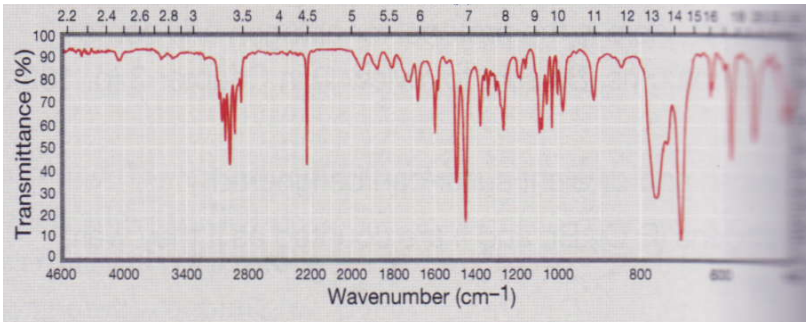
a) alcohol, carboxylic acid, or phenol



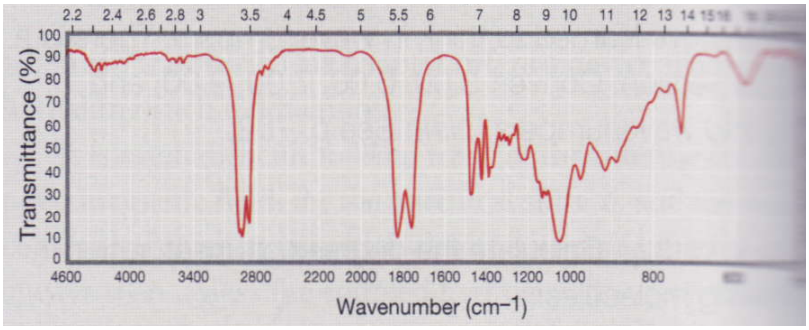

b) aldehyde, ester, or ketone




c) 1-alkyne, symmetrical internal alkyne, or nitrile

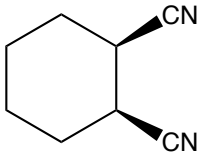


d) anhydride, carboxylic acid, or ester




8) (24 pts) Devise (below and on the following blank page) a synthesis for the following transformations using any reagents that we have discussed, the indicated starting material, and any other stable organic starting materials needed. If you need more space, please use the back of this sheet and direct me there. For **FULL** credit be sure to show the retrosynthetic analysis AND the complete synthesis.

a)

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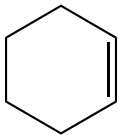
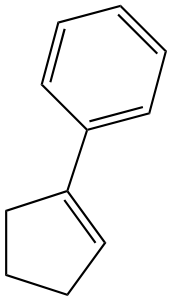


b)



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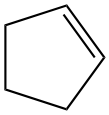

| **Functional Group** | **Frequency ($cm^{-1}$)** | **Intensity and Comments** |
|---|---|---|
| Alkanes | | |
| C–H | 2980-2850 | medium to strong |
| C–C | 1480-1420 | medium |
| Alkenes | | |
| =C–H stretch | 3150-3000 | medium; very weak for trans |
| =C–H bend | 980-960 (trans) | strong |
| | 730-665 (cis) | strong |
| C=C | 1680-1600 | weak to medium |
| Alkynes | | |
| ≡C–H | 3350-3300 | strong |
| C≡C | 2260-2100 | weak to medium |
| Alkyl halides | | |
| C–Cl | 800-600 | strong |
| C–Br | 600-500 | strong |
| C–I | 500 | strong |
| Alcohols | | |
| O–H | 3650-3300 | strong and broad |
| C–O | 1350-1050 | strong |
| Amines | | |
| N–H | 3500-3100 | medium and strong; 1° amines-2 bands; 2° amines-1 band |
| C–N | ~1200 | medium |
| Aromatics | | |
| C–H stretch | 3080-3020 | weak to medium |
| C–H bend | 900-730 | strong |
| C=C | 1650-1580 | weak to medium |
| Carbonyls (C=O) | | |
| Ketones | 1730-1700 | strong |
| Aldehydes | 1730-1700 | strong; also has a O=C-H doublet at ~2700 & 2800 $cm^{1}$ |
| Esters | 1750-1735 | strong; also has C–O stretch |
| Amides | 1680-1630 | strong; 1° and 2° amides also have N-H stretch |
| Acids | 1730-1700 | strong; also has O–H stretch |
| Acid Anhydride | 1850-1740 | strong; doublet |
| Acid Chlorides | 1820-1770 | strong |
| Nitrile (C≡N) | 2200-2250 | medium |
| Nitro ($NO_2$) | Doublet at: 1570-1550 & 1380-1360 | strong |