1. (6 points) Provide IUPAC accepted names for the following compounds.

\[ \text{3-chloro-2,4- dimethylhexane} \quad \text{3-cyclopropyl-1,4-pentadiene} \]

2. (6 points) Provide a structure for the following compounds.

\[ \text{p-ethylphenol} \quad \text{sec-butyl bromide} \]

3. (8 points, 2 each) Provide an example of a molecule containing the indicated functional group. Do not include more than one functional group in each compound you draw.

a) ester \[ \text{CH_3COOCH_2CH_3} \]

b) carboxylic acid \[ \text{CH_3COOH} \]
c) amine \[ \text{CH_3NH_2} \]
d) alkyl halide \[ \text{CH_3Br} \]

4. (6 points) Draw the lowest energy chair conformation of cis-1-t-butyl-2-fluorocyclohexane. Clearly show the H’s on C1 and C2 and label both substituents as either axial or equatorial.

5. (6 points) Provide the missing electron-pushing arrows for the following reaction sequence. Some steps should be redrawn to clearly show lone pairs or bonds that are involved in the reactions.

\[ \text{Ph}_3\text{P}^+ + \text{CH}_3\text{Br} \rightarrow \text{Ph}_3\text{PCH}_3^+ + \text{Br}^- \]

\[ \text{Ph}_3\text{PCH}_3 + \text{Br}^- \rightarrow \text{Ph}_3\text{PC}^+ + \text{CH}_4 + \text{LiBr} \]

\[ \text{Ph}_3\text{P} = \text{CH}_2 \]

\[ \text{Ph}_3\text{P}^+ + \text{CH}_3 \rightarrow - \]

\[ \text{Ph}_3\text{P} = \text{CH}_2 \]
6. (9 points) For each of the following pairs of reactions, circle the reaction that proceeds faster.

a. 
\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{H}_2\text{NCH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2\text{CH}_3 + \text{Br}^- \]
\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{NaNH}_2\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NHCH}_3 + \text{NaNBr} \]

b. 
\[ (\text{CH}_3)_2\text{CHCH}_2\text{ONa} + \text{CH}_3\text{Br} \xrightarrow{\text{DMSO}} (\text{CH}_3)_2\text{CHCH}_2\text{OCH}_3 + \text{NaBr} \]
\[ (\text{CH}_3)_2\text{CHCH}_2\text{ONa} + \text{CH}_3\text{Br} \xrightarrow{(\text{CH}_3)_2\text{CHCH}_2\text{OH}} (\text{CH}_3)_2\text{CHCH}_2\text{OCH}_3 + \text{NaBr} \]

c. 
\[ \text{Cl}_2 \xrightarrow{\text{AlCl}_3} \begin{array}{c} \text{Cl} \\ \text{phenol} \end{array} \]
\[ \text{Cl}_2 \xrightarrow{\text{AlCl}_3} \begin{array}{c} \text{Cl} \\ \text{acetophenone} \end{array} \]

7. (5 points) Determine the absolute configuration of all stereocenters in the following compound. Show your reasoning.

8. (5 points) Classify the following alkene as E or Z. Show your reasoning.
9. (10 points, 2 each) Circle the aromatic structures.

10. (6 points, 3 each) Classify each of the following reactions as either addition, elimination, substitution, or rearrangement reactions.
   a) \[ \text{CH}_3\text{CH}_2\text{MgBr} + \text{CH}_3\text{CCH}_3 \rightarrow \text{CH}_3\text{CCH}_3 \]  
      \[ + \text{Et}_2\text{O} \rightarrow \text{CH}_3\text{CCH}_3 \text{ addition} \]
   b) \[ \text{O} \text{Cl} + \text{CH}_3\text{OH (excess)} \rightarrow \text{O} \text{OCCH}_3 \]  
      \[ + \text{CH}_3\text{OH} + \text{Cl}^- \text{ substitution} \]

11. (4 points, 2 each) Calculate the oxidation state of the indicated carbons.

12. (6 points, 3 each) Classify each of the following reactions as oxidation, reduction, or neither. You do NOT need to provide the reagents necessary to complete the reactions.
   a) \[ \text{C-C} \rightarrow \text{O} \text{OH} \text{ neither (no net change in total ox. #s on C's.)} \]
   b) \[ \text{C=C} \rightarrow \text{Br} \text{ oxidation (net + change on C's.)} \]

13. (6 points) Calicene has an unusually large dipole moment for a hydrocarbon. Explain why.

   calicene
   Calicene has an important resonance contributor in which both rings are aromatic.
14. (6 points, 3 each) For each set, circle the compound that is most basic.
   a) 
   \[ \text{CH}_3\text{CH}_2\text{OH}_2 \] \[ \text{CH}_3\text{CH}_2\text{OH} \] \[ \text{CH}_3\text{CH}_2\text{ONa} \]
   b) 

15. (6 points, 3 each) For each set, circle the compound that is most acidic.
   a) 
   \[ \text{CH}_3\text{SH} \] \[ \text{CH}_3\text{NH}_2 \] \[ \text{CH}_3\text{OH} \]
   b) 

16. (15 points, 5 each) For each of the following Bronsted-Lowry acid/base reactions
   a. provide products that would form if the reaction proceeds as written
   b. label the acid and base on each side of the reaction
   c. draw an arrow indicating which way the equilibrium actually lies

\[
\text{HC} \cdot \text{CNa} \quad \text{base} \quad + \quad \text{CH}_2=\text{CH}_2 \quad \text{acid} \quad \rightarrow \quad \text{HC} \equiv \text{CH} \quad + \quad \text{CH}_2=\text{CHNa} \quad \text{c.A.} \quad \text{c.B.}
\]

\[
\text{CH}_3\text{CH}_2\text{Li} \quad \text{base} \quad + \quad \text{CH}_3\text{CH}_2\text{NH}_2 \quad \text{acid} \quad \rightarrow \quad \text{CH}_3\text{CH}_3 \quad + \quad \text{CH}_3\text{CH}_2\text{NHCl} \quad \text{c.A.} \quad \text{c.B.}
\]

\[
\text{C} \equiv \text{OH} \quad + \quad \text{CH}_3\text{ONa} \quad \text{acid} \quad \text{base} \quad \rightarrow \quad \text{C} \equiv \text{ONa} \quad + \quad \text{CH}_3\text{OH} \quad \text{c.B.} \quad \text{c.A.}
\]

17. (42 points, 3 each) Provide the major organic products for the following reactions. Be sure to indicate stereochemistry when necessary.

\[
\text{CH}_3\text{C} \equiv \text{CH} \quad 1) \quad \text{BH}_3, \text{ether} \quad \text{2) H}_2\text{O}_2, \text{NaOH, H}_2\text{O} \quad \rightarrow \quad \text{CH}_3\text{CH}_2\text{CH}_3
\]
18. (12 points, 4 each) Determine if each of the following pairs of compounds represent enantiomers, diastereomers, constitutional isomers, or two molecules of the same compound.

- Constitutional isomers
- Same
- Diastereomers

19. (10 points) Match each of the given IR spectra to one of the following compounds. Label at least one peak in each IR spectrum that allows you to conclusively match spectrum to compound.
For your convenience ...

A

B

C

D

E
20. (10 points) Determine the structure of the following C_{10}H_{14} compound. Partial credit will be awarded if you solve pieces of the final structure and show your reasoning. Place your final answer in the box.

^{13}C NMR (δ, ppm): 148, 128, 127, 126, 42, 31, 22, 12

^{1}H NMR:

IR:

\[ \frac{10 \times (2) + 2 - 14}{2} = 4 \text{ units unsaturation} \]
22. (16 points) Provide a complete electron-pushing mechanism and the corresponding energy diagram for the following reaction. Label and draw starting materials, transition state(s), intermediate(s), products, and axes on the diagram. Show the structure(s) of any transition state(s).
24. (10 points) Provide a synthesis for one of the following two compounds. You may use organic reagents containing three carbons or less and any inorganic reagents you need. Clearly indicate which one you are omitting.

**Synthesis A**

\[ \text{HC} \equiv \text{C} \equiv \text{C} \equiv \text{Na} + \text{BrCH}_{2} \text{CH}_{2} \text{CH}_{3} \rightarrow \text{HC} \equiv \text{C} \equiv \text{C} \equiv \text{C} - \text{CH}_{2} \text{CH}_{2} \text{CH}_{3} \]

**Synthesis B**

\[ \text{H}_{2} \text{C} = \text{CH} - \text{CH}_{2} \text{CH}_{3} \]

I pledge that I will not discuss the contents of the exam with anyone prior to 6 pm on Thursday, May 10 and that I did not use notes, texts, or the assistance of others during the exam.

______________________________
signature