Solve the following problems in the space provided. You have 55 minutes to complete this closed book, closed notes exam. When you are in doubt, rely on your logic rather than vague memories. Write down what you do know to ensure some credit. Budget your time according to the point value of the problem. It is better to do most of an exam well than all of it poorly.

1. Circle all of the stereocenters in the following molecule. What is the maximum number of stereoisomers possible for this compound? (8 points)
Name all the functional groups (using an arrow rather than a circle) in this molecule and classify any alcohols, amines or alkyl halides. (8 points)

2. Define the relationship (if any) that exists between each pair of molecules given below, i.e., are they the same, structural isomers, geometric isomers (cis/trans or Z/E), diastereomers, enantiomers or do they have no relationship? (18 points, six points each)

a. 

- enantiomers
  vs.
b.

\[
\begin{align*}
&\text{vs.} \\
&\text{No relationship} \\
&\text{Different IHD}
\end{align*}
\]

c.

\[
\begin{align*}
&\text{Same molecule,} \\
&\text{Congruent bond rotation}
\end{align*}
\]

3. Write all the stereoisomers of the molecule shown below and using the Cahn-Ingold-Prelog system give a stereochemical designation (Z/E or R/S) to each stereocenter. Indicate all relationships among the molecules (indicate enantiomers and diastereomers). (18 points)

\[
\text{CH}_3\text{CH}_2\text{CH}(\text{CH})(\text{CH})_2\text{C}(\text{CH}_3)(\text{CHO})\text{CH}_2\text{CH}_3
\]
4. Write a complete and acceptable IUPAC name for each of the following structures. Your answer should include the Cahn-Ingold-Prelog stereochemical designation if appropriate. (20 points)

\[
\begin{align*}
5\text{-}(3\text{-bromopropyl}) & \quad 2\text{-}10\text{-dimethyl} \\
9\text{-cyclopentyl} & \\
1\text{-}, 3\text{-}, 8\text{-undecatrien\text{-}5\text{-ol}} & \\
(3E), (8E),(5S) - 5\text{-}(3\text{-bromopropyl}) - 9\text{-cyclopentyl} - 2\text{-}10\text{-dimethyl} - 1\text{-}, 3\text{-}, 8\text{-undecatrien\text{-}5\text{-ol}}
\end{align*}
\]

5. Which of the following molecules can be represented as two or more geometric isomers? In cases where geometric isomerism is possible, clearly draw all geometric isomers and label them cis and trans (where applicable, Z or E is also acceptable). In cases where geometric isomerism is not possible, briefly explain. (18 points)

a. 

b. \(\text{CH}_3\text{CH}_2\text{CCCHCH(CH}_3\text{)}\)

hint: focus on the central ring

c. 

\text{Not stereocenters}

\text{2 It on once C}
6. Consider the following molecular formula: \( \text{C}_{14}\text{H}_{15}\text{N}_{2}\text{O}_{2}\text{Br} \)

a. Calculate the IHD (degree of unsaturation/unsaturation number) for this formula (6 points).

\[
\begin{align*}
\text{SF} & \quad \text{C}_{14}\text{H}_{31}\text{N}_{2}\text{O}_{2}\text{Br} \\
\text{AF} & \quad \text{C}_{14}\text{H}_{15}\text{N}_{2}\text{O}_{2}\text{Br} \\
& \quad \frac{16}{2} = 8
\end{align*}
\]

b. Using a skeletal (bond-line) representation, draw a structure that is consistent with the given molecular formula having a cyclic ester, a secondary amine, a nitrile and an asymmetric carbon having the "R" absolute configuration among the various structural elements. (10 points)

![Structure Diagram]

7. Rank the following molecular pairs in terms of the likelihood of separation using conventional laboratory methods. Number 1 ranking = most facile separation. (6 points)

a.  

b.  

Kind of a toss up between

b4-c but @ cannot be separated

Same

c.  

No Relationship

Meso, but not same
8. Circle any structures in problem 7. that are meso. (6 points)

9. The circled nitrogen in 8-fluoropurine (structure shown below) is considered to be sp² hybridized.

![Structure of 8-fluoropurine]

a. Is that what you would have predicted? If not, write your hybridization prediction. What is your hybridization prediction for the other nitrogens in 8-fluoropurine? (8 points)

   \[
   \begin{align*}
   \text{sp}^3 & \quad \text{would have been predicted} \\
   \text{Rest} & \quad \text{sp}^2
   \end{align*}
   \]

b. Using the sp² hybridization for the circled hydrogen and your predictions for the other atoms in 8-fluoropurine, draw an orbital representation of the five membered ring found in this structure (include the fluorine in your representation). Indicate which atomic and hybrid orbitals contribute to molecular orbitals. Be sure to show nonbonded pairs and their associated orbitals. (16 points)