Solve the following problems in the space provided. You have a maximum of 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 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 at primary secondary or tertiary. (8 points)
Is this molecule chiral? (2 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), enantiomers or do they have no relationship? (20 points, four points each)

a. trans-1-bromo-3-chlorocyclopentane vs. 

b. 

No relationship

enantiomers
c. 

![Chemical structure 1](image1)

VS.

![Chemical structure 2](image2)

No relationship

d. 

![Chemical structure 3](image3)

VS.

![Chemical structure 4](image4)

SAME

e. 

![Chemical structure 5](image5)

VS.

![Chemical structure 6](image6)

Structural isomers

3. Write all the stereoisomers of the molecule shown below using a proper three dimensional molecule and using the Cahn-Ingold-Prelog system give a stereochemical designation (Z/E or R/S) to each stereocenter. You must explicitly show the structures including bonds for all molecules. Define all relationships between molecules. (20 points)
4. Write a complete and acceptable IUPAC name for each of the following structures. Your answer should include the Chan-Ingold-Prelog stereochemical designation if appropriate. (20 points)

a. 

b. 

5. Consider the following molecular formula C_{14}H_{16}N_{2}O_{4}Br.

   a. Calculate the IHD (unsaturation number) for this formula (8 points)

   \[ \text{IHD} = 8 \]

   b. Using a skeletal representation (bond line), draw a structure that is consistent with the given molecular formula having a cyclic anhydride (an anhydride in a ring), a tertiary amine, an acyl halide and an asymmetric carbon having the “R” configuration among the various structural elements. (16 points)
6. 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. (24 points)

a. cyclopentene

b. CH$_3$CH$_2$CCCHC(CH$_3$)$_2$

No

Ring is too small to accommodate double bond

two groups same on d.b.

Cis

Trans

c. 1,4-dibromocyclobutane
d. hint: focus on the central ring

7. The circled nitrogen in adenine (structure shown below) is considered to be sp$^2$.

![Adenine structure](image)

a. Is this what you would have predicted? If not, write your hybridization prediction. (6 points)

b. Using a sp$^2$ hybridization for the circled nitrogen, draw a complete orbital representation of adenine. Indicate which atomic and hybrid orbitals contribute to the molecular orbitals. (12 points)
c. Which type of orbital is holding the lone pair electrons on each nitrogen in the molecule? (6 points)

\[ \text{sp}^3, \text{sp}^2, \text{and } \rho \]

as shown on diagram

7. Rank the following molecular pairs in terms of the likelihood of separation using conventional laboratory methods. Number 1 ranking = most facile separation. Identify all meso compounds among the compounds below. Identify any compounds that would have an optical rotation among the compounds below. (16 points)

a. 

Hardest to separate

b. 

Easiest to separate

Meso

No relationship

c. 

Chiral

Meso

Diastereomers