1. Draw structure of an epoxide, a beta-lactam, and a four-carbon reducing sugar in the open-chain form. Place charges, if present, on appropriate atoms. (9 pts)

2. Which of the following terms best describes each pair of compounds shown below: (20 pts)
   a. Conformational isomer
   b. Enantiomers
   c. Diastereomers
   d. Meso compound
   e. Same molecule
   f. All of the above
   g. None of the above

   ![Conformational Isomer](image)
   ![Enantiomers](image)
   ![Meso Compound/Same Molecule](image)
3. Circle chiral centers in the following molecules. If there are no chiral centers in a molecule, write NONE. Note: Each chiral center should contain only one atom. Negative points for identifying centers that are not chiral centers. (14 pts)

[Diagrams of Reserpine and β-D-Glucose]

4. Identify the chirality of all the chiral centers in the following molecules. Use ‘R’ or ‘S’ nomenclature. (8 pts)

[Diagrams of two molecules with chiral centers marked]

5. The isomer on the left is more extensively hydrolyzed in our body than the isomer on the right. Why? (4 pts)

[Diagrams of two molecules with different configurations]

Our body utilizes enzymes to metabolize molecules. These enzymes usually recognize molecules specifically, e.g., a specific stereoisomer is usually recognized. The isomer on the left is therefore likely to be metabolized extensively.
6. Draw a chair conformer of a six-membered reducing monosaccharide with the following distribution of groups: –OH groups at 1 and 3 are axially oriented, while those at 2 and 4 are equatorial. The –CH₂OH group at 5 position is equatorial (4 pts). Draw its conformational isomer that might exist in equilibrium (4 pts). Circle the isomer that more stable of the two. (1 pts)

7. Consider reactions A) and B). Circle the reaction that has a shorter half-life? (4 pts)

8. Draw the structure of following natural α–amino acids at pH 12 in their stereochemically correct form (‘S’ stereochemistry according to Cahn-Ingold-Prelog convention). Use bold and cross-hatched lines to show ‘S’ stereochemistry. Indicate appropriate charges (12 pts)

9. Write the systematic name of the following heterocycles. (12 pts)
10. Rank the following compounds on their ability to undergo hydrolysis at pH 1 (H^+ / H_2O). Use 1 for most easily hydrolyzable and 3 for least. **NOTE: Entire sequence has to be correct to get any points.** (6 pts)

```
2
3
1
```

11. Draw product(s) of the following hydrolytic reactions assuming that complete hydrolysis is occurring. Write appropriate charges on functional groups formed in the reaction. If there is no product, write NONE. (22 pts)

A) ![Reaction](image)

B) ![Reaction](image)

C) ![Reaction](image)

D) ![Reaction](image)

12. Define the following terms: (12 pts)

1) **Meso Compounds** _Stereoisomers containing more than one chiral center that possess a plane of symmetry such that mirror image isomers are superimposable_

2) **Diastereomers** _Pair of stereoisomers containing more than one chiral center that are not related as mirror image isomers_
3) Enantiomers are mirror image stereoisomers that are non-superimposable.

13. Predict the product(s) of the following reactions. If there is no product, write NONE. (15 pts)

A) \[ \text{nitration} \]
\[
\begin{align*}
\text{OH} & \quad \rightarrow \\
\text{NO}_2 &
\end{align*}
\]

B) \[ \text{bromination} \]
\[
\begin{align*}
\text{Cl} & \quad \rightarrow \\
\text{SO}_3\text{H} &
\end{align*}
\]

C) \[ \text{metabolic oxidation} \]
\[
\begin{align*}
\text{Br} & \quad \rightarrow \\
\text{NO}_2 &
\end{align*}
\]

14. Indicate whether the following compounds will exhibit good water solubility at pH 7.2 – 7.4. Circle the correct answer. (12 pts)

A) Soluble, Insoluble

B) Soluble, Insoluble

C) Soluble, Insoluble

15. Rank the following molecules according to the basicity of –NH\(_2\) group. Use 1 for most basic and 4 for least. (12 pts)

16. Rank the following molecules according to their acidity. Use 1 for most acidic and 3 for least acidic. (9 pts)
17. Circle ionizable functional group(s) (pH range 0 - 14) in the following molecules and indicate their approximate pKₐ value or range. **NOTE:** If there are no ionizable groups on the molecule, write **NONE.** Also, -1 point for identifying an ionizable functional group, which does not ionize in the pH range 0–14. (20 pts)

- **Dantrolene** (Muscle Relaxant)
  - Ionizable groups: 6-8, 8-10

- **Lomefloxacin** (antibacterial)
  - Ionizable groups: 3-5, 8-11

- **Saxitoxin** (a toxic anesthetic)
  - Ionizable groups: >11

- **Muscarine**
  - Ionizable groups: none

- **Nicotine**
  - Ionizable groups: 4-6, 8-11