I. (44 points)

A. Complete the following reactions as directed.

(a) [Chemical structure image]

- **i)** major product
- **this stereochem only**

(b) [Chemical structure image]

- **i)**
- **ii)** Draw a Newman Projection for the conformation of the C1-C2 bond indicated that specifically undergoes this reaction.
- **This stereochem only**

iii) This reaction demonstrates (check the best answer)
- [ ] regioselection
- [X] stereoselection
- [ ] regio- and stereoselection
- [ ] neither regio- nor stereoselection

B. For each of the following compounds, identify any/all sources of stereochemistry and label the site(s) with the appropriate R/S, cis/trans, E/Z label(s). If no label can be given, please write "NONE" in the box. no partial credit

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

Provide the letters corresponding to the compounds shown above (A-E) to answer the following questions. If none of the compounds above apply, please write "none" in the box.

- **i)** Which of the compounds above (A - E) has a chiral diastereomer? **BC**
- **ii)** Which of the compounds above (A - E) is optically inactive? **CE**
- **iii)** Which of the compounds above (A - E) has an enantiomer? **ABD**
II. (42 points)

A. Pseudomonic Acid A - PA-A - is the primary ingredient found in Bactroban, an antibiotic being used to treat Methicillin-Resistant Staph A (MRSA).

(a) Find and label all sites that have stereochemistry.

(b) For each of the atoms indicated with an arrow above, provide the atom's most reasonable hybridization as well as its electronic (VSEPR) geometry, and its observable geometry (shape). (no partial credit)

<table>
<thead>
<tr>
<th>Atom</th>
<th>Hybridization</th>
<th>Electronic (VSEPR) geom.</th>
<th>Obs. geom (shape)</th>
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<td>C₁</td>
<td>sp³</td>
<td>tetrahedral</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>C₂</td>
<td>sp²</td>
<td>trig planar</td>
<td>trigonal planar</td>
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<tr>
<td>O₂</td>
<td>sp²</td>
<td>Trigonal planar</td>
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</table>

B. Each of the following transformations yields one major product (i.e. no mixtures of stereoisomers or regioisomers). Draw this product for each.

a)  

b)  

c)  

d)
III. (36 points)

A. Use the energy diagram at the right to answer the following questions. Be sure to show the sign for each energy change.

(i) How many transition states are represented by the diagram? 3 pts
(ii) Estimate the $\Delta G_{rxn}$ for the reverse (G to A) transformation. 4 pts
(iii) Estimate the $E_a (\Delta G^\ddagger)$ for the C to A step in the reverse reaction. 10 pts
(iv) Estimate the $\Delta G^\ddagger$ for the E to C step in the reverse (G to A) reaction. -15 pts
(v) What is the $E_a (\Delta G^\ddagger)$ for the rate determining step for the complete A to G transformation? C to D + 25 pts

B. Consider the following reaction:

(i) This reaction yields (check one):

- one unique compound
- a racemic mixture
- a mixture of 2 diastereomers
- a mixture of 3 or more stereoisomers

(ii) The energy diagram above (in Part A) could be used to represent the energy changes that occur during the above reaction. Using this to guide you, draw the curved arrow mechanism for this complete transformation.

B. Predict the product(s) for each of the following transformations. If the product forms as a stereoisomeric mixture, draw one showing stereochemistry clearly, and write "+ enantiomer" or "+ diastereomer" in the box.

(i) The product is drawn clearly and labeled with stereochemistry. 4 pts
(ii) The reaction is labeled with "+ enantiomer" and must be drawn 3D. 4 pts
IV. (36 points)

A. Each of the following reactions yields only two major products. Draw these products, showing all stereochemistry clearly, and define their relationship.

(a) 
\[ \text{H}_2 \xrightarrow{\text{Ni}} \text{products} \]
Relationship between these two products: Enantiomers

(b) 
\[ \text{H}_2\text{O} \xrightarrow{\text{H}_2\text{SO}_4 \text{ (cat.)}} \text{products} \]
Relationship between these two products: Regioisomers

(c) 
\[ \text{Br} \xrightarrow{\text{heat}} \text{products} \]
Relationship between these two products: Enantiomers

(d) 
\[ 1) \text{9-BBN} \]
\[ 2) \text{H}_2\text{O}_2/\text{NaOH} \]
Relationship between these two products: Diastereomers

B. Resonance can be used to predict the most likely proton transfer that can occur in the following reaction. Draw all products, showing a complete set of resonance contributors for the conjugate base. Estimate the Keq for the reaction.

\[ \text{products} \]
Relationship between these two products: 5

C. Draw all organic product(s) that result from the following transformation.

\[ \text{products} \]
Relationship between these two products: 4
V. (40 points)

A. For each of the following pairs, check all the descriptions that apply. no partial credit

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</table>

B. Provide the complete IUPAC name, including stereochemistry if needed, for:

- \((R,E)-3,5,5,6\text{-tetramethyloct-3-ene}\)
- \((S)-3,3\text{-dibromo-4,4-dimethylcyclopentanol}\)

C. Methylisothiocyanate is one of the most powerful lachrymators (tear gases) in the world. It is best represented by a set of resonance contributors. Contributor A is drawn for you, draw the other all closed shell contributors (atomic formal charges must be between +1 and -1).

**contributor A**

Assuming the hybridization model for all atoms (considering both resonance contributors) provide an accurate and complete three-dimensional orbital picture for contributor A, using lines, dashes, wedges, and p orbitals (lone or overlapping) to show the direction of all electrons (or empty orbitals) in your drawing. All bond angles should reflect the appropriate geometry and hybridization chosen for your drawing.
A. The following dehydration reaction yields a variety of structurally isomeric products, one of which is drawn for you. Draw the others, given the information provided.

B. When an optically pure starting material is used in each of the following transformations, optically active product(s) result. Draw all major optically active products that form.

C. Compound Z undergoes E2 reactions to yield a single product. Show the conformation (chair) that undergoes E2 and provide the structure of the product that forms. Make sure to show axial and equatorial positions for any ring atom that is substituted.