1. (a) (6 points) Write two resonance structures for acetone (2-propanone). Clearly indicate all appropriate π-bonds, lone pairs of electrons, and formal charges. CIRCLE the most important resonance structure.

(b) (6 points) Write a resonance structure for uracil to explain its aromatic character. Clearly indicate all multiple bonds, lone pairs of electrons, and formal charges.

(c) (6 points) The base catalyzed interconversion of imines is an important process in the oxidation of amino acids. Write a resonance structure that has no formal charge on any atom for the neutral intermediate formed in this process. The intermediate is formed by deprotonation of the pyridinium cation shown below. Clearly indicate all multiple bonds and lone pairs of electrons.
(d) (8 points) Ascorbic acid (vitamin C) has a pKa of 4.2. CIRCLE the most acidic hydroxyl group of vitamin C. Why is this proton so acidic? Explain with a short sentence and by drawing two resonance structures for the anion of ascorbic acid.

![Ascorbic Acid (Vitamin C)](image)

Deprotonation at the indicated oxygen gives an anion in which charge is delocalized over 2 oxygens.

2. Draw the structures of the following compounds

(a) (4 points) Complete the drawing of meso-2,3-dibromobutane

![meso-2,3-dibromobutane](image)

(b) (4 points) para-aminobenzoic acid (PABA, used in sunscreens, formula C₇H₇NO₃)

![para-aminobenzoic acid](image)

(c) (4 points) The amino acid glycine.

![Glycine](image)

(d) (4 points) 3-methylbutyl pentanoate (apple flavor)

![3-methylbutyl pentanoate](image)
(e) (8 points) Draw the most stable chair form of both trans- and cis-1,3-dimethylcyclohexane.

Draw a TRIANGLE around an AXIAL methyl group.

Draw a BOX around an EQUATORIAL methyl group.

\[
\text{cis-1,3-dimethylcyclohexane} \quad \text{trans-1,3-dimethylcyclohexane}
\]

3. (a) (6 points) CIRCLE the oxidizing agents; draw a BOX around the reducing agents; at least one of the reagents is neither an oxidizing or reducing reagent

\[
\text{CrO}_3 \quad \text{Na}_2\text{CO}_3 \quad \text{NaBH}_4 \quad \text{Cl}_2 \quad \text{HBr} \quad \text{Mg}
\]

(b) (5 points) CIRCLE the aromatic compounds:

(c) (6 points) CIRCLE the compound which reacts fastest in an \( S_N2 \) reaction with NaI. Draw a BOX around the compound which reacts slowest in an \( S_N2 \) reaction with NaI.
(d) (6 points) **CIRCLE** the compound which reacts fastest in an electrophilic aromatic substitution with Br₂ and FeBr₃. Draw a **BOX** around the compound which reacts slowest in an an electrophilic aromatic substitution with Br₂ and FeBr₃.

4. (8 points) Histamine is the chemical messenger that antihistamine medicines try to block. Histamine is released during an allergy attack and can produce multiple biological effects including asthma, watery eyes, and runny nose. The two pKₐ values of histamine are 6.9 and 10.4. [For reference, the pKₐ of protonated imidazole is 7.0 and the pKₐ of protonated ethylamine is 10.7.] Draw the major form of histamine present at pH = 2.0. Draw the major form of histamine present at pH = 8.0.

5. Complete the following reactions by providing the required starting material, reagents, or products.

(a) (6 points)

\[ \text{HBr} \]
(b) (6 points)

\[
\begin{align*}
\text{\text{HCl}} & \quad \text{H}_2\text{O} \\
100^\circ\text{C} & \quad \rightarrow \\
\end{align*}
\]

(c) (6 points) Show the stereochemistry of the product

\[
\begin{align*}
\text{Br} & \quad \text{H} \\
\quad & \quad \rightarrow \\
\text{Na}^+ & \quad \text{SCH}_3 \\
\end{align*}
\]

(d) (6 points) Show all products

\[
\begin{align*}
\text{KOC(Me)}_3 & \quad \text{HOOC(Me)}_3 \\
\quad & \quad \rightarrow \\
\end{align*}
\]

(e) (6 points)

\[
\begin{align*}
\text{CH}_3 & \quad \text{HNO}_3 \\
\text{H}_2\text{SO}_4 & \quad \rightarrow \\
\end{align*}
\]

(f) (6 points)

\[
\begin{align*}
\text{SO}_3\text{H} & \quad \text{Br}_2 \\
\text{FeBr}_3 & \quad \rightarrow \\
\end{align*}
\]
(g) (8 points) Show how the alcohol shown below can be made from compounds with 6 carbons or less (hint, one route involves a Grignard reagent).

(h) (6 points) Draw the product of the following crossed aldol condensation

(i) (6 points)

6. (8 points) Kevlar is a polyamide that is used in bullet proof jackets. Draw the structures of the two components used in the synthesis of Kevlar.
7. (12 points) The structure of sucrose (table sugar) is shown below.

CIRCLE the anomeric carbon atoms.
Draw an ARROW to a glycosidic linkage.
Sucrose has ___ asymmetric centers,
___ aldose units, ___ ketose units,
___ furanose units, ___ pyranose units.

8. (a) (8 points) Write a mechanism for the acid catalyzed conversion of the cyclic hemiacetal to the cyclic acetal shown below. Show all intermediates and use "electron pushing arrows" to show how each intermediate is converted to the next.
(b) (8 points) Write a mechanism for the following reaction. Show all intermediates and use "electron pushing arrows" to show how each intermediate is converted to the next.

\[
\text{OCH}_3 \quad \xrightarrow{\text{NaOH}} \quad \text{Na}^+ \quad + \quad \text{CH}_3\text{OH}
\]

9. (5 points) Pose a question that you studied for and was not asked on this exam. You will be graded both on the quality of your question and your answer.
10. (20 points) Indicate the RELATIONSHIP between the following structures.

(a) Check all that apply:
- [ ] enantiomers
- [ ] diastereomers
- [x] conformers
- [ ] same
- [ ] structural isomers

(b) Check all that apply:
- [x] enantiomers
- [ ] diastereomers
- [ ] conformers
- [ ] same
- [ ] structural isomers

(c) Check all that apply:
- [ ] enantiomers
- [x] diastereomers
- [ ] conformers
- [ ] same
- [ ] structural isomers

(d) Check all that apply:
- [ ] enantiomers
- [x] diastereomers
- [x] epimers
- [ ] anomers
- [ ] structural isomers

(e) Check all that apply:
- [ ] enantiomers
- [x] diastereomers
- [x] epimers
- [x] anomers
- [ ] structural isomers
11. (8 points) Rapamycin is a macrocyclic lactone antibiotic produced by a microorganism found in Easter Island's soil. This remarkable molecule was approved by the FDA for use as an immunosuppressant in 1999.

Rapamycin

Rapamycin has 15 asymmetric centers. There are 3 ketone functional groups.

CIRCLE an ester functional group. Draw a BOX around a hemiacetal functional group.

1____  6____  Circle the name of your TA  
2____  7____  Kim Smith
3____  8____  Eric Benedict
4____  9____  Nate Bowling
5____  10____  Salwa Salah

TOTAL______  Ramon Sanchez