1. (34 points) Show the major product or products expected from each reaction.

(a) \[ \text{Excess HCl} \]

(b) \[ \text{Br}_2, \text{H}_2\text{O} \]

(c) \[ 1) \text{O}_3, 2) \text{H}_2\text{O}_2 \]

(d) \[ \text{H}_3\text{C} - \text{OCH}_3 \]

(continued on next page)
2. (12 points) Shown below is a drug called ritonavir for patients infected with HIV. CIRCLE all sp³ stereogenic centers, and indicate whether each configuration is R or S.

+1 for each correct circle
+2 for each correct S
3. (23 points) Show the reagents required to convert the starting molecule to the indicated product. If necessary, be sure to differentiate clearly between distinct steps, by using "1)," "2)," etc. over the arrow.

(a)

```
   CH₂=CH₂
      ▶️
   [Any peracid OK] ▶️
   O
   H
   (d)
```

(b)

```
   CH₂CH₂CH₃
       ▶️
   Hg(OH)₂, H₂O ▶️
   H₂SO₄
   CH₃COCH₃
```

(c)

```
   TsO⁻CH₂CH₂CH₃
       ▶️
   Na⁺ \overset{6}{\text{C≡C-CH₂CH₃}}
   CH₂CH₂CH₃
```

(d)

```
   CH₃O⁻CH₂CH₃
       ▶️
   optical isomer  ▶️
   C₆H₅COCH₃
   CH₃O⁻CH₂CH₃
```
4. (24 points) Reaction (i) below produces three products, A, B and C. A and B are isomers, and these compounds each react with one equivalent of H₂ in the presence of Pd/C to produce the same product. Reaction (ii) produces only one product (D).

(a) Draw the products in the indicated boxes below.

If C is in A or B, it is not a valid product. Total score is 3/15 for 0/5 A → C.

(b) Explain in ONE SENTENCE why only one product is formed in reaction (ii).

Molecule D is aromatic while other possible products would be non-aromatic. No mention of benzene or aromatic is worth 0/4.
5. (20 points)

(a) The reaction shown below leads to two isomeric products. Draw those products.

(b) Draw the most stable conformation of each product.

These + anti-Mark. products = 2 per (±) indicators -1 ea.

C w/o Hs -1

If labeled backwa., -1 ea.

Only 1 Mark prod. w/ stereochem + opp chair lines w/o Hs -1 ea. 4& + 4

or other same b/c of messing w/ tBu carbon... 4/8 & 0/12 (if chairs correct.

wedges/dashes on otherwise correct chairs = 4/0
6. (8 points) For each equilibrium shown below, CIRCLE the side that you would expect to be favored.

(a) $\text{CH}_3\text{CO}^-\text{Na}^- + \text{F}^\text{F}\text{F}^\text{F}\text{C}^\text{C}^-\text{O}^\text{H} \rightleftharpoons \text{CH}_3\text{CO}^\text{H} + \text{F}^\text{F}\text{F}^\text{F}\text{C}^\text{C}^-\text{O}^-\text{Na}^-$

(b) $\text{K}^+\text{O}^-\text{C}^-\text{C}^\text{C}^-\text{O}^\text{H} \rightleftharpoons \text{HO}^-\text{C}^-\text{C}^\text{C}^-\text{O}^\text{K}^+$

(c) $\text{H}_3\text{C}^\text{C}^-\text{C}^\text{C}^-\text{CH}_3 \rightleftharpoons \text{H}_3\text{C}^-\text{C}^\text{C}^-\text{CH}_3$

(d) $\text{NH}_3^+\text{Cl}^- + \text{Na}^-\text{NH}_2^- \rightleftharpoons \text{NH}_2^- + \text{NH}_3^- + \text{Na}^+\text{Cl}^-$
7. (30 points) Provide a mechanism (curved arrows) for each reaction shown below. Be sure to show intermediates and all important resonance structures.

(a) \[ \text{cat. NaOH} \quad \xrightarrow{\text{CH}_3\text{OH}} \quad \text{OH} \quad \xrightarrow{\text{Na}^+} \quad \text{Na}^+ \]

(b) \[ \text{HCl} \quad \xrightarrow{\text{Cl}^-} \quad \text{Cl}^- \quad \xrightarrow{\text{H}^+} \quad \text{Cl}^- \]

[Ok if CH₃OH]
8. (25 points) When the starting material shown below is allowed to react under the conditions shown, two isomeric products result, A and B. B is chiral and racemic, but A is not chiral. Compound A forms only one product, A-1 (not chiral), under the second reaction conditions, but compound B forms two new products under the second reaction conditions, B-1 and B-2. B-1 and B-2 are both chiral and racemic. Draw the structures of all five compounds in the indicated boxes.

A =

B =

A-1 =

B-1 =

B-2 =

-1 each for no H's on CH₂
9. (24 points) Devise a synthetic route from the indicated starting material to the indicated target in each of the two cases below. Each route should be as short and as selective as possible. You may use any other organic molecules and any inorganic reagents in your synthetic plans. Show the expected product after each step in each synthetic route. (Do not provide mechanistic information.)

(a)

Starting material =

\[
\begin{align*}
\text{Target} = & \quad \begin{array}{c}
\text{H} \\
\text{D} \quad \text{H}
\end{array} \\
\text{D} & \quad \text{H}
\end{align*}
\]

\[\text{NaO}^-, \text{NH}_3\]

+4

\[\text{H}_2 \text{ poisoned catalyst}\]

\[\text{D}_2, \text{Pd/C} \quad (+2 \text{ if as alkene})\]

\[\text{ok to use ND}_3 \text{ in 1st step, and}\]

\[\text{H}_2 \text{ in 2nd step}\]
9. (cont.)

Starting material =

\[
\begin{align*}
\text{\(\alpha, \text{HBr, peroxides} \quad (+8)\)} & \quad \downarrow \\
\text{\(\text{B} \text{(III, THF)} \)} & \quad \downarrow \\
\text{\(\text{H}_2\text{O}_2 \rightarrow \text{NaOH, } \text{H}_2\text{O} \)} & \quad \downarrow
\end{align*}
\]

\[
\begin{align*}
\text{\(\text{HO} \quad \text{Br} \quad (+4) \)} & \quad \downarrow \\
\text{\(\text{PBr}_3 \)} & \quad \downarrow \\
\text{\(\text{SOCl}_2 \quad \text{or} \quad \text{TsCl/Pyr \ ok.} \)} & \quad \downarrow
\end{align*}
\]

\[
\begin{align*}
\text{\(\text{Br} \quad (+4) \)} & \quad \downarrow \\
\text{\(\text{CH}_3-\text{C} \equiv \text{C} \cdot \Theta \quad \text{NBr} \quad (+4) \)} & \quad \downarrow \\
\text{\(-2 \text{ if } \text{H} \equiv \text{CH} \)} & \quad \downarrow
\end{align*}
\]

\[
\begin{align*}
\text{\(-4 \downarrow \quad \text{H}_2, \text{Pd/C} \)} & \quad \downarrow
\end{align*}
\]

Target =

\[
\begin{align*}
\text{\(\text{OH} \quad \text{H}_2\text{SO}_4 \quad \text{H}_2\text{O} \quad (+4) \)} & \quad \downarrow \\
\text{\(+4 \downarrow \quad \text{Pd/C} \)} & \quad \downarrow
\end{align*}
\]