This exam is worth 100 points out of a total of 600 points for Chemistry 3720/3720L. You have 50 minutes to complete the exam; read the questions carefully. Good Luck.

1. (10 pts) *Give the products* from each step of the following sequence as well as a *complete step-by-step mechanism* for the entire conversion that *includes important resonance structures* for intermediates.
2. (20 pts) Give the **major organic product from each step** in the following sequences.

**a.**
1. NaOH, CH₃OH, Δ
2. (CH₃)₂CuLi, THF
3. aq. NH₄Cl (quench)

**b.**
1. Br₂, CHCl₃
2. NaOCH₃, CH₃OH
3. NaBH₄, CH₃OH

**c.**
1. xs CH₃OH, cat. H⁺
2. H₂, Pd
3. 5% aq. HCl, RT, 3 h

**d.**
1. PhMgBr, ether, 0 °C
2. aq. NH₄Cl (quench)
3. m-CPBA, CH₂Cl₂

**e.**
1. dilute H₂SO₄
2. PCC, CH₂Cl₂
3. m-CPBA, CH₂Cl₂
3. (10 pts) Give a complete mechanism, including important resonance structures for any intermediate(s) that may be formed, that explains the formation of the major product in the following reaction. Explain briefly why you get more of one product than the other.

\[ \text{HN(CH}_3\text{)}_2, \text{cat. TsOH} \rightarrow \]

\[ \begin{array}{c}
\text{major}
\end{array} \]

The more highly substituted enamine (alkene) will be favoured (Zaitsev)

4. (6 pts) Circle the more stable species in the following two situations and give a few words of explanation for your choice in each case.

The iodoform test is for methyl ketones
5. (10 pts) Provide the product and a complete mechanism for its formation (including important resonance structures) in the following reaction.
6. (16 pts) Give the major organic product from each step in the following road map.

7. (8 pts) Provide a detailed mechanism for the following conversion that includes important resonance structures for any intermediates that are formed.
8. (10 pts) *Explain why* the following synthesis does not work, then give *conditions that will allow* for the product from the given starting material and *show the products from each step* of your pathway.

\[
\begin{align*}
\text{HCO}_2\text{CH}_3 & \xrightarrow{2 \times \text{CH}_3\text{MgBr, ether}} \text{HCO}_2\text{CH}_3 \\
& \xrightarrow{\text{aq. NH}_4\text{Cl (quench)}} \text{HCO}_2\text{CH}_3
\end{align*}
\]

The given conditions won’t lead to the desired product; the aldehyde is actually more reactive than the ester so the Grignard would attack there faster. Blocking (protecting) the aldehyde first as an acetal (CH$_3$OH was chosen to avoid complications with the ester group) would temporarily remove the aldehyde from consideration (nucleophiles, e.g. Grignard reagents, do not react with acetals) thus allowing for manipulation of the ester group. The aldehyde can be regenerated by hydrolysis using aqueous acid.

9. (10 pts) *Give a retrosynthetic analysis* for the following molecule that goes back to the given starting materials, and then *provide the synthesis in the forward direction*. Assume you have access to the usual other reagents (HBr, HNO$_3$, NaBH$_4$, etc.) in the lab.

**Retrosynthesis**

\[
\begin{align*}
\text{Br} & \quad \leftrightarrow \quad \text{OH} \\
\text{OH} & \quad \leftrightarrow \quad \text{O} \\
\text{O} & \quad \leftrightarrow \quad \text{O} \\
\text{O} & \quad \leftrightarrow \quad \text{OH} \\
\text{PCC} & \quad \text{CH}_2\text{O}_2 \quad \text{OH} \quad \text{CH}_3\text{OH} \quad \text{NaBH}_4 \quad \text{HBr} \quad \text{Br}
\end{align*}
\]

The 6-carbon framework and a 3-carbon starting material suggests aldol chemistry to make the required C-C bond. The rest of the chemistry is functional group interconversions.

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