1. (6 pts) Name 3 out of 4 of the following compounds: Cross one out or graded in order.

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{O} & \quad \text{O} & \quad \text{CH}_3 \\
\text{CH}_3 & \quad \text{O} & \quad \text{Br} & \quad \text{H} \\
\text{O} & \quad \text{O} & \quad \text{O} & \quad \text{H} \\
\text{NC} & \quad \text{O} & \quad \text{C} & \quad \text{H}_3
\end{align*}
\]

2. (14 pts) For top sequence provide reagents. For bottom sequence fill in the products.

\[
\begin{align*}
\text{Br} & \quad \xrightarrow{1. \text{ A/Et}_2\text{O}} & \quad \xrightarrow{2. \text{ B/ no workup}} & \quad \text{O} & \quad \xrightarrow{\text{C}} & \quad \text{O} & \quad \xrightarrow{\text{D}} & \quad \text{O} & \quad \text{H} & \quad \text{CH}_3 \\
\text{C}_{\text{H}_3} & \quad \text{NBS} & \quad \xrightarrow{\text{FRI}} & \quad \text{NaCN} & \quad \xrightarrow{\text{1. LAH}} & \quad \xrightarrow{\text{DMF}} & \quad \xrightarrow{\text{2. Acid workup}} & \quad \text{H} & \quad \text{CH}_3
\end{align*}
\]

3. (12 pts) Given that Nitroethane has a pK_a=9. This is compared to the C-H in ethane, pK_a=50.

(a) Circle the very acidic protons in nitroethane and write the products of the acid base reaction.

\[
\begin{align*}
\text{N} & \quad \text{CH}_2 & \quad \text{CH}_3 \\
\text{O} & \quad \text{O} & \quad \text{Na}^+ \quad \text{OH}^-
\end{align*}
\]

(b) Predict the direction of this reaction. \(K_{eq} = \) 

(c) Explain why nitromethane is so acidic compared to ethane. Draw 2 resonance structures.
4. (8 pts) Of the following acids, 
p-methoxybenzoic acid  p-nitrobenzoic acid  p-bromobenzoic acid  benzoic acid

Rank order of acidity:
Most acidic ______________________  2nd most acidic ______________________
3rd most acidic ______________________  Least acidic ______________________

5. (8 pts) Draw the structures for the $\beta$-ketoenol and the $\beta$-ester enol forms. 
Given $pK_a(O-H)\sim16$, $pK_a(\alpha-H)\sim20$, $pK_a(double- \alpha-H)\sim9$.

\[
\text{B-keto enol form} \quad \xrightarrow{} \quad \text{B-ketoester form} \quad \xrightarrow{} \quad \text{B-ester enol form}
\]

There is one more possible enol. Draw it and explain why it is the least stable enol form.

Which form is most stable and why?

6. (4 pts) The most effective way of making a cyclic anhydride is to start with a cyclic alkene, react with $O_3$, and then dehydrate. Fill in the sequence below.

ozonolysis \quad \xrightarrow{} \quad \text{dehydration} \quad \xrightarrow{-H_2O} \quad \text{dehydration}

5. (20 pts) Alpha-hydroxy acids are very popular skin care aids, advertised as chemical “skin peels”. An efficient preparation for alpha-hydroxy acids is through the cyanohydrin synthesis, followed by acid hydrolysis. Which compounds would be used to make the following alpha-hydroxy acids. The name of the aromatic acid is mandelic acid. What is the common name for alpha hydroxy acid in part a?

(a)

(b)
(c) Below is the mechanism for the acid catalyzed hydrolysis of mandelonitrile to mandelic acid. Show the electron flow: You will have to provide lone pairs when necessary. I gave you a few.

(d) What is the role and purpose of the proton from the hydronium ion, needed to start the reaction?

6. (12 pts) Fill in the empty boxes with the letter that will provide the best reagents for the synthesis of 3,3-dimethylindanone. Then draw the product.
   a. Cl₂, HOAc
   b. NaOEt, ethanol, heat
   c. 1. PhMgBr, ether
      2. H₂O
   d. 1. Mg, ether
      2. CO₂
      3. H₃O⁺
   e. I₂, NaOH(aq)
   f. H₂SO₄, heat
   g. 1. (Ph)₂CuLi, ether
      2. H₂O⁺
   h. 1. LDA, THF
      2. (CH₃)₂CHBr
   i. SOCl₂

```
   H₃C
   CH₃
   C=O
   CH₃
   CH₃
   H₃C   -->   CH₃
   CH₃
   O       -->       CH₃
   CH₃
   CH₃
   acid workup
   CH₃
   OH
   CH₃
   AlCl₃
   CH₃
   Cl

   3,3-dimethylindanone
```
7. (12 pts) Provide products for the following reaction sequences: Choose 3 out of 4 and cross one out or graded in order.

OO
1. NaOEt, HOEt
2. Et-Br
3. H₃O⁺, heat

C₂H₅

O
1. PBr₃, Br₂
2. Aqueous acid workup

O
1. LDA
2. Benzyl bromide

C
Nitro
1. MeMgBr
2. H₃O⁺ workup

7. (8 pts) Finish either sequence A and sequence B.

Sequence A

EtOH, H⁺

LAH

Sequence B

EtOH, H⁺

1. LDA
2. CH₃Br