There are nine pages (2–10) of questions in this exam. The exam is closed-book and closed-notes, and no electronic devices are allowed.
(1) (3 points each, 12 points total) Please provide the product of the illustrated reactions. If no reaction is expected, write "NR".

- $\text{Me} = \text{CHMe}_2$
- $\text{Me} = \text{CHMe}_2$
- $\text{Ph} = \text{C}_6\text{H}_5$
- $\text{H}_2\text{C}=\text{PPh}_3$
- $\text{H}_2\text{C}=\text{PPh}_3$
- $\text{HCN}$
- catalyst: $\text{H}^+$
- $\text{CrO}_3/\text{H}_2\text{O}/\text{H}^+$
- catalyst: $\text{H}^+$
- $\text{NH}_2\text{Me}$
- catalyst: $\text{H}^+$
(2) (3 points each, 15 points total) Please provide the reagents/conditions that are necessary to achieve the illustrated reactions.

- Ph –CN → Ph –CH₂NH₂

- Ph –COOMe → Ph –OH

- Ph –Cl → HO Me Me Ph

- Ph –CMe → HO Me Me Ph

- Ph –COOH → Ph –Cl
(3) (12 points each, 24 points total) Please provide a synthesis of the indicated target molecule from the indicated starting material, showing all key reagents and conditions. There is no need to show a mechanism/arrow-pushing for your synthesis.

(a)

Starting material

Target molecule
(b)

\[
\text{starting material: } \begin{array}{c}
\text{Me} \\
\text{Me} \\
\text{CO} \\
\text{Me}
\end{array}
\]

\[
\text{target molecule: } \begin{array}{c}
\text{Me} \\
\text{Me} \\
\text{HO} \\
\text{Me}
\end{array}
\]
(4) (12 points) Provide the best mechanism for the illustrated reaction. Please show all arrow pushing.

\[
\begin{align*}
\text{N} &\quad \text{Me} \\
\text{O} &\quad \text{H}_2\text{O} \\
\text{1 equivalent of H}^+ &\quad \text{HO} \quad \text{NH}_3 \quad \text{Me} \quad \text{CO}_2\text{H}
\end{align*}
\]
(5) (11 points) An amide hydrolysis performed under basic conditions in labeled water was stopped before the reaction was complete. The "unreacted" amide contained mostly labeled oxygen in the carbonyl oxygen. Please provide the best explanation for this observation, including a mechanism for the formation of the labeled amide (with all arrow pushing).

(a) (5 points) Mechanism:

(b) (6 points) Explanation:
(6) (15 points total) Methyl acetimidate (A) is hydrolyzed in aqueous sodium hydroxide to (initially) give mainly acetamide and methanol (eq 1). In aqueous acid, A hydrolyzes to (initially) give primarily methyl acetate and the ammonium ion (eq 2).

(a) (5 points) Please provide the best mechanism for the illustrated process, showing all steps and all arrow-pushing.

\[
\begin{align*}
\text{A} & \quad \xrightarrow{\text{excess } H^+} \quad \text{Me} \quad \overset{\text{NH}}{\overset{\text{O}}{\text{Me}}} \\
\text{Me} \quad \overset{\text{O}}{\overset{\text{Me}}{\text{NH}}_2} & \quad + \quad \text{MeOH} \\
\end{align*}
\]

(b) (5 points) Please provide the best mechanism for the illustrated process, showing all steps and all arrow-pushing.

\[
\begin{align*}
\text{A} & \quad \xrightarrow{\text{excess } H^+} \quad \text{Me} \quad \overset{\text{O}}{\overset{\text{Me}}{\text{Me}}} \\
\text{Me} \quad \overset{\text{O}}{\overset{\text{Me}}{\text{NH}_4}} & \quad + \quad \text{MeOH} \\
\end{align*}
\]
(c) (5 points) Please clearly and succinctly explain why the two reactions provide different products.
(7) (11 points) Provide the best mechanism. Please show all arrow pushing.