1. (12) For the reactions shown below, write the (i.e., one) major organic product in the corresponding box. Do not include any mechanism details. Assume reactants above or below the arrow to be in excess. If no reaction occurs, write "NR" in the product box. *Hint: Organic products contain carbon.*

(a) ![Reaction A](image1.png)

(b) ![Reaction B](image2.png)

(c) ![Reaction C](image3.png)

(d) ![Reaction D](image4.png)

2. (3) Draw in the box the structure of another carbonyl-containing molecule that gives the same product as question 1(d), but reacts as quickly as, or even faster than the molecule in question 1(d).

3. (2) Why doesn't a ketone undergo nucleophilic carbonyl substitution? Write one or more letters in the answer blank. Answer choices: (a) Not enough $\delta^+\text{C}=\text{O}$; (b) too much steric hindrance; (c) too much resonance stabilization; (d) tetrahedral intermediate is too unstable; or (e) none of these reasons. Answer(s): ____________.
4. (6) For each equilibrium shown below, write "">", "<", or ""=" in the $K_{eq}$ blank.

(a) \[
\begin{array}{c}
\text{Ph} \\
\text{OCH}_3
\end{array}
\text{O} + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \begin{array}{c}
\text{Ph} \\
\text{OCH}_3
\end{array}
\text{O} + \text{CH}_3\text{OH} \quad K_{eq} \quad 1
\]

(b) \[
\begin{array}{c}
\text{Ph} \\
\text{OCH}_3
\end{array}
\text{O} + \text{CH}_3\text{SH} \rightleftharpoons \begin{array}{c}
\text{Ph} \\
\text{SCH}_3
\end{array}
\text{O} + \text{CH}_3\text{OH} \quad K_{eq} \quad 1
\]

(c) \[
\begin{array}{c}
\text{Ph} \\
\text{OCH}_3
\end{array}
\text{O} + \text{CH}_3\text{OH} \rightleftharpoons \begin{array}{c}
\text{Ph} \\
\text{OCH}_3
\end{array}
\text{OCH}_2\text{CH}_3
\quad K_{eq} \quad 1
\]

5. (2) Shown below is an example of the Birch reduction reaction. Note the carbons of the reactant are numbered. Complete the statement below writing one or more numbers in each blank. If none of the carbons meet the requirement, write '0' in the blank.

\[
\begin{array}{c}
\text{C}_5 \\
\text{C}_4 \\
\text{C}_3 \\
\text{C}_2 \\
\text{C}_1
\end{array}
\text{OCH}_3
\quad 1. \text{Li, HOC(CH}_3)_2
\quad 2. \text{H}_2\text{O}^+
\quad \begin{array}{c}
\text{C}_5 \\
\text{C}_4 \\
\text{C}_3 \\
\text{C}_2 \\
\text{C}_1
\end{array}
\text{OCH}_3
\]

In this Birch reduction reaction, carbon number(s) ________ are reduced and carbon number(s) ________ are oxidized.

6. (6) Write a mechanism for the acid-catalyzed conversion of acyclic glucose into glucopyranose shown below.

\[
\begin{array}{c}
\text{HO} \\
\text{HO}
\end{array}
\text{C}_1 \quad \text{H}_2\text{O}^+ \quad \begin{array}{c}
\text{HO} \\
\text{HO}
\end{array}
\text{C}_1
\]

7. (2) The reaction of question 6 is slower when \text{H}_2\text{O}^- is omitted. In the answer blank write the letter(s) of all the reasons that account for this rate difference. Answer choices: (a) \(\delta^+\text{C}=\text{O}\); (b) steric hindrance; (c) better nucleophile, and (d) decrease in resonance stabilization. Answer(s): ____________.
8. (10) Write a mechanism for this reaction. *You may use H-B and B for this problem, but not anywhere else on Final Exam Part A.*

\[ \text{苯甲酸} \xrightarrow{\text{H}_2\text{SO}_4} \text{苯甲酸酯} \]

9. (10) Write a complete mechanism for this enzyme-catalyzed reaction of retinal (R = conjugated carbon group) and opsin (P = rest of protein) to form rhodopsin. The enzyme has a weakly acidic site (EnzB-H) and a weakly basic site (EnzB).

\[ \text{Retinal} + \text{Opsin} \xrightarrow{\text{EnzB-H}} \text{Rhodopsin} \]

10. (2) In lecture we learned of the three fundamental, common carbonyl fates. Write the name(s) of all the carbonyl fates *not present* in your mechanism in question 9.
11. (3) Protein synthesis involves coupling the carboxyl group of one amino acid with the amino group of another amino acid. However, the carboxyl group must be converted into a phosphate before this can happen:

![Chemical diagram]

Complete this sentence by adding no more than ten words: Hydroxyl must be converted into phosphate before coupling because the hydroxyl group...

Diphosgene is a chemical weapon first deployed in 1917. This weapon was developed because diphosgene is safer to handle than phosgene, and because diphosgene isn't filtered out by gas masks designed to handle phosgene. Instead, new gas masks containing NaOH or Ca(OH)$_2$ had to be distributed to handle diphosgene. Questions 12–16 concern synthesis of diphosgene and chemistry of the diphosgene gas mask.

12. (2) Write in the box the reactant(s) needed to complete this synthesis of diphosgene from phosgene:

![Chemical diagram]

Shown below is the reaction by which diphosgene is detoxified (neutralized) in the gas mask. The phosgene produced by this reaction continues to react with NaOH, forming an additional carbonate ion.

![Chemical diagram]

13. (4) Write the mechanism for conversion of diphosgene into molecule A (reaction I).

14. (6) Write the mechanism for conversion of molecule A into carbon dioxide and phosgene (reaction II).
15. (4) Complete the following sentence by writing 'I' or 'II' in the blank, then *add no more than ten words*. Reaction ________ is faster because compared to molecule A, diphosgene has...

16. (3) Although not discovered until the 1940's, NaBH₄ might also be useful to detoxify diphosgene. Write the product for the reaction of diphosgene with excess NaBH₄ without any solvent present. *Hint: Work through the mechanism (but please don't write the mechanism here).*

17. (2) In the box write the letter of the reaction site (A, B, C, or D) when this molecule is deprotonated with NaOCH₃:

18. (6) Complete each of the following reactions by writing the major organic product(s) in the boxes. If two or more products are formed in roughly equal amounts, write all of these products. If no reaction occurs, write "NR" in the product box. Assume the reactants above and below the arrow are present in excess. *Do not provide any mechanism details.*

Hint for (b): The product is yellow, and has molecular formula C₁₇H₁₄O.

19. (2) Complete this sentence by writing *one letter* in the blank: The reaction of question 18(b) is an example of __________. Answer choices: (a) aldol condensation; (b) Claisen condensation; (c) Fischer esterification; (d) Chichibabin reaction; or (e) none of these.

Page 5 score = [Blank]
20. (7) Write a mechanism for the following reaction:

\[
\begin{align*}
\text{H}_3\text{CO} & \quad \text{OCH}_3 \\
\longrightarrow & \quad \text{OCH}_3 \\
\text{2. H}_3\text{O}^+ & \quad \text{OCH}_3
\end{align*}
\]

21. (2) Write the name of one carbonyl-containing functional group that does not appear in any question on part A of this exam. A carbonyl-containing functional group that appears in one of your answers is acceptable, as long as it does not appear in any question. If all carbonyl-containing functional groups covered in Chem 14D are represented in this exam, write "none" in the answer space.

22. (2) Write one number such as 97 or number and letter such as 97(q) in the blank. If no problems meet this requirement, write '0' in the blank. In exam Part A, problem number ________ includes an organometallic compound.

23. (2) Using no more than twenty words and no structures define: Tetrahedral intermediate.