1. (2) Complete this statement by writing **no more than five words in each blank**: The rate of any mechanism step is controlled by the difference between ______________________________________ and ____________________________________ for that mechanism step.

2. (7) For the following **S$_{N}$2 reaction**: (a) write the curved arrows; (b) complete the transition state drawing, and (c) write the major product in the product box.

   \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{Cl} \\
   \text{Na}^+ \text{SCH}_3 \\
   \text{CH}_2\text{OH} \\
   \text{Cl} \\
   \text{H}_3\text{C} \rightleftharpoons \text{C} \\
   \end{array}
   \]

   Product

3. (10) For each change to the reaction of question 2, write 'F' in the blank if the change makes the reaction faster, 'S' if the change makes the reaction slower, and 'N' if the change has no significant effect on the reaction rate. **Note that these changes are not cumulative; for example the change in part (b) does not also include the change in part (a).**

   (a) Na$^+$SCH$_3$ changed to Na$^+$SeCH$_3$: _______
   (b) Cl changed to I: _______
   (c) CH$_3$OH changed to DMF: _______
   (d) 2-Chlorobutane changed to 1-chlorobutane: _______
   (e) Na$^+$SCH$_3$ changed to CH$_3$CO$_2$Na$: _______

4. (2) In the answer box write the letter of molecule that ionizes most quickly when ethanol is the solvent.

   \[
   \begin{array}{cccc}
   \text{A} & \text{B} & \text{C} & \text{D} \\
   \text{CH}_3 \text{OSO}_2 \text{CF}_3 \\
   \end{array}
   \]

   Answer

5. (4) In the first box write the major product of this reaction. In the second box write another product formed in a significant amount. If no significant second product is formed write an X in the second product box. **"NR" (no reaction) is not a viable answer for this problem.**

   \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{CH}_3 \\
   \text{Br} \\
   \text{CH}_3\text{CH}_2\text{OH} \\
   \end{array}
   \]

   Major product

   +

   Another significant product

Page 1 score =
6. (8) Write the mechanism for the formation of the molecule in the question 5 major product box.

Questions 7–10 concern this reaction:

7. (2) Complete this sentence by writing one or more letter(s) in the blank. The most likely mechanism for this reaction is __________. Mechanism choices: (a) S_N2; (b) S_N1; (c) E2; (d) E1, and (e) EAS.

8. (4) In the first box above write the major product of this reaction. In the second box write another product formed in a significant amount. If no significant second product is formed write an X in the second product box. "NR" (no reaction) is not a viable answer for this problem.

9. (2) Write the curved arrow mechanism that shows the formation of the major product for this reaction.

10. (2) Complete this blank by writing no more than three words in the blank: The major product for this reaction is formed in accordance with ___________________________________________ rule.

11. (2) Complete the following reaction by writing the missing reactant(s) in the box:

12. (6) Write the mechanism for the reaction in question 11.
13. (4) Complete these sentences by writing **exactly one word** in each blank: The major reaction product shown in question 11 can be predicted using _________________ rule. In this case, the rule is based on _________________ stability.

14. (9) For the reactions shown below, write the (i.e., one) major organic product in the corresponding box. Do not include any mechanism details. If no reaction occurs, write "NR" in the product box. **Hint:** Organic products contain carbon.

(a) \[ \text{Aromatic Compound} \xrightarrow{Br_2, h\nu} \]  

(b) \[ \text{Aromatic Compound} \xrightarrow{\text{aq. HNO}_3, \text{aq. H}_2\text{SO}_4} \]  

(c) \[ \text{Aromatic Compound} \xrightarrow{\text{(CH}_3)_2\text{CCl}, \text{AlCl}_3} \]  

15. (2) In the space below rewrite the reaction of question 14(c) so that it gives exactly the same product, but it occurs at an obviously and significantly faster rate. **Include the starting material, all reactants, and product of the reaction but do not include any mechanism details.**

16. (2) Give the name or molecular structure (including the radical electron) of a free radical encountered in Chem 14D that has been implicated in damage to biological systems.

17. (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; and (e) none of these reasons. Answer(s): _______________.

Page 3 score =
18. (2) For the equilibrium shown below, write ">", "<", or "=" in the $K_{eq}$ blank.

\[
\begin{align*}
\text{Ph} & \quad \text{OCH}_3 \\
\text{+ CH}_3\text{SH} & \quad \leftrightarrow \\
\text{Ph} & \quad \text{SCH}_3 \\
\text{+ CH}_3\text{OH} & \quad K_{eq} \quad \text{1}
\end{align*}
\]

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

![Mechanism diagram]

20. (2) The reaction of question 19 is slower when H$_3$O$^+$ is omitted. In the answer blank write the letter(s) of all the reasons that account for this rate difference. Answer choices: (a) $\delta^+$C=O; (b) steric hindrance; (c) better nucleophile, and (d) decrease in resonance stabilization. Answer(s): ____________.

21. (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 B.

![Reaction diagram]
22. (1) In lecture we learned of the three fundamental, common carbonyl fates. Write the name(s) of all the carbonyl fates \textit{not present} in your mechanism in question 21.

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. Shown below is the reaction by which diphosgene is detoxified (neutralized) in the gas mask.

\[
\begin{align*}
\text{Diphosgene} & \quad \xrightarrow{\text{NaOH}} \quad \text{Molecule A} \quad \xrightarrow{\text{NaOH}} \quad \text{Phosgene} \\
& \quad \xrightarrow{\text{CO}_2 + \text{Cl}} \quad \text{Carbonate}
\end{align*}
\]

23. (4) Complete the following sentence by writing 'I' or 'II' in the blank, then \textit{add no more than ten words.}

Reaction \underline{_______} is faster because compared to molecule A, diphosgene has...

24. (2) In the box write the letter of the reaction site (A, B, C, or D) when this molecule is deprotonated with NaOCH$_3$:

25. (3) Complete the following reaction by writing only the one major organic product in the box. 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. \textit{Do not provide any mechanism details.}