Winter 2025 **Chemistry 2600 Final Exam** ____/95 marks

**Confidentiality Agreement:**
I agree not to discuss (or in any other way divulge) the contents of this exam with (or in the presence of) any CHEM 2600 student who has yet to write it. I understand that breaking this agreement would constitute academic misconduct. The minimum penalty would be a mark of 0/95 on this exam.

Signature: _____ Date: _____

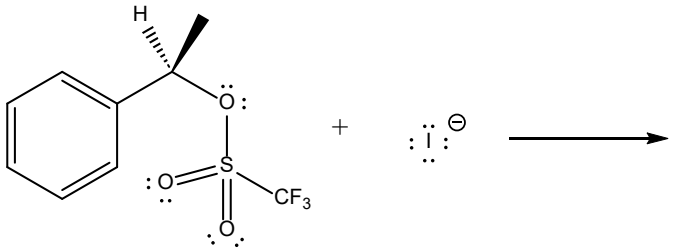
1) Please read the test carefully before starting. It has thirteen pages of questions and a periodic table.
2) You have been given a 6-page Spectroscopy Data Package. **PLEASE DO NOT WRITE ON THE SPECTROSCOPY DATA PACKAGE**! If you need scrap paper, use the back of any page of the test. On questions with spectra, you may also do rough work directly on the spectra.
3) You are allowed to bring one index card (maximum size 3"x5") into the exam with you as a "cheat sheet". This card must be submitted with your exam.
4) You may use a molecular model kit and ruler. You may not have written materials in your model kit.
5) You may use a calculator but only for calculation. No other electronic devices are allowed.
6) **DO NOT WRITE ON ANY QR CODE!!!** Work on pages without a QR code will not be graded.
7) If your work is not legible, it will be given a mark of zero. For full credit, explanations must be complete. In many cases, complete explanations include drawing relevant structures. If delocalization of electrons is invoked, the relevant resonance structures must be drawn.
8) Marks will be deducted for incorrect information added to an otherwise correct answer.
9) You have 3 hours to complete this test.

**Question Breakdown**

| Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| / 5 | / 6 | / 4 | / 9 | / 9 | / 10 | / 18 | / 28 | / 5 | / 1 | | | | | / 95 |

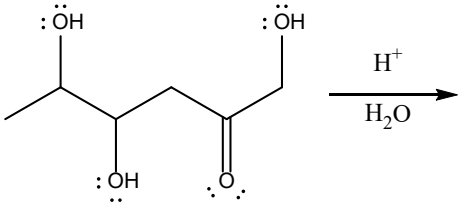
1. Indicate whether or not you would expect to see a significant amount of reaction according to each mechanism type by circling 'yes' or 'no'. In the bottom row of each table, justify your answer by: **[5 marks]**
   - For each 'yes', drawing the organic product(s) that will be observed. If multiple regioisomers and/or stereoisomers can be produced via that mechanism, draw each of them.
   - For each 'no', briefly explaining why you expect little-to-no reaction.

   *The marks are for the product(s) and/or explanations. The yes/no part is just to help you think.*



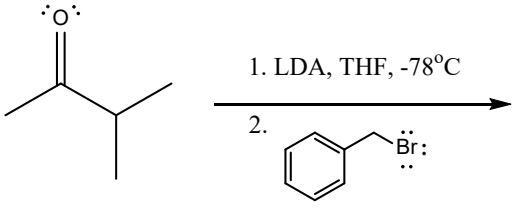

| **$S_N1$?** yes / no | **$S_N2$?** yes / no | **E1?** yes / no | **E2?** yes / no |
|---|---|---|---|
| | | | |

2. Draw the hemiacetal that is expected to form when the sugar below is in aqueous acid **and** draw a reasonable mechanism for its formation. **[6 marks]**

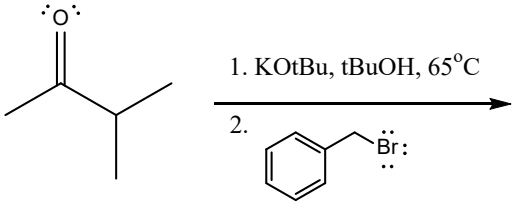



3. Draw the major organic product for each of the following reactions. **[4 marks]**

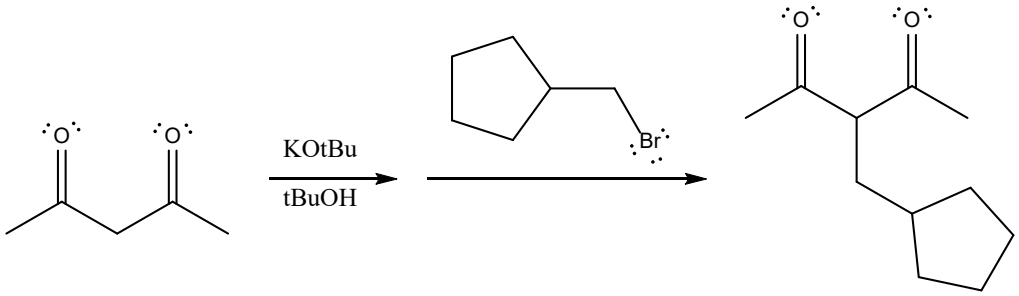
(a)




(b)



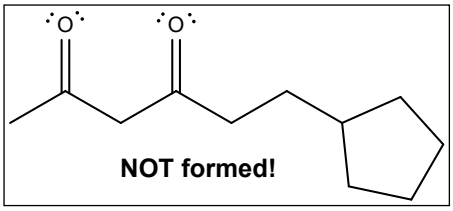
4. Consider the following reaction. **[9 marks]**




(a) Draw a reasonable mechanism for this reaction. *[3 marks]*

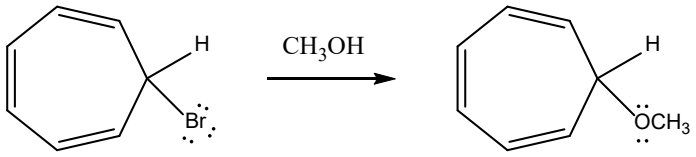
(b) Explain why the compound below is **not** also formed. *[6 marks]*

*For full marks your answer must address what would have to have happened to form the compound below and why the reaction above is better.*

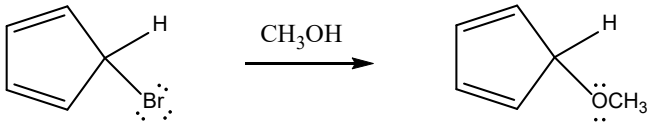


5. Reaction A proceeds much more rapidly than Reaction B. **[9 marks]**

**Reaction A**




**Reaction B**

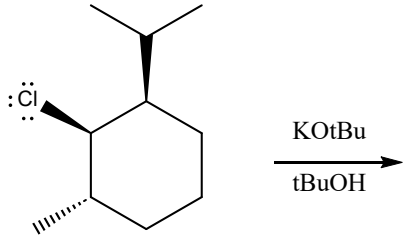



(a) Draw a reasonable mechanism for Reaction A. *[5 marks]*

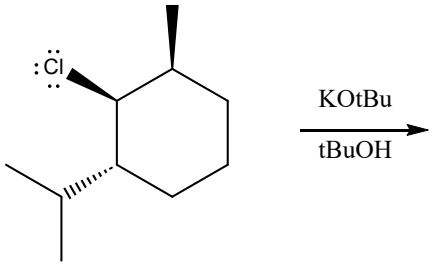
(b) Explain why Reaction A is faster than Reaction B. *[4 marks]*
*For full marks your answer must address the key component(s) of both reactions.*

6. Consider the following reactions, each of which proceeds via an $E2$ mechanism. **[10 marks]**

**Reaction A**




**Reaction B**

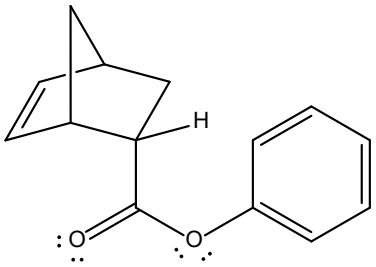


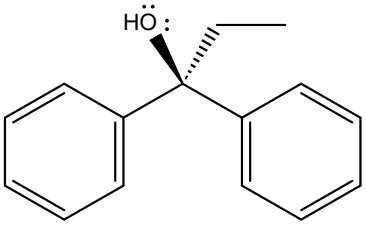

(a) Complete each reaction equation by drawing the major organic product. *[4 marks]*

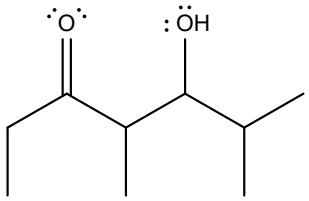
(b) Which of these two reactions would you expect to proceed faster? Why? *[6 marks]*

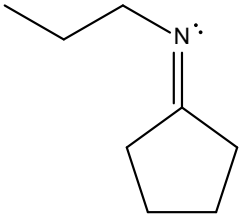
*For full marks your answer must include at least one relevant diagram for each reaction.*

7. Choose any **three** of the molecules below and propose a synthesis for each one. **[18 marks]**
   - If your synthesis involves more than one step, write an equation for each step. Show all required reactants. Number steps within a reaction if order of addition is important.
   - All organic reactants must be stable compounds containing **no more than five carbon atoms**. They may be **hydrocarbons, alkyl halides or alcohols** and may contain C=C or C≡C bonds. The only exception to this rule is that you are **also allowed** to use **benzene, bromobenzene or phenol**.
   - If you wish to use an organic reactant (including Grignard reagent) that does not meet these requirements, you must show how to make it from starting materials that do.
   - You may use any inorganic reagents, acids, bases, catalysts, etc.
   - Acids, bases, catalysts, etc. do not need to meet the "organic reactant" requirements if the organic part will not be present in the final product.
   - Clearly indicate stereochemistry of reaction products where appropriate. Assume that all stereochemistry shown is relative and that you are to make racemic product.
   - You are **not** required to show mechanisms for this question.
   - There are three pages after this page. Use one of those pages for each synthesis and clearly identify the synthetic target at the top of the page. This page is scrap paper.
   - If you give more than three syntheses, I will only mark the first three (ignoring any that are crossed out).



7. *continued…* *[6 marks]*

**Synthetic Target #1:**

**Synthesis:**

7. *continued…* *[6 marks]*

**Synthetic Target #2:**

**Synthesis:**

7. *continued…* *[6 marks]*

**Synthetic Target #3:**

**Synthesis:**

8. The following pages contain spectra for Unknown X ($C_9H_8O_4$). **[28 marks]**

(a) Identify Unknown X based on these spectra. Draw your answer in the box provided below.

(b) Use this page to explain your reasoning. Integrals have been provided under each peak or set of peaks on the $^1$H NMR spectrum, so you do not need to calculate them this time.

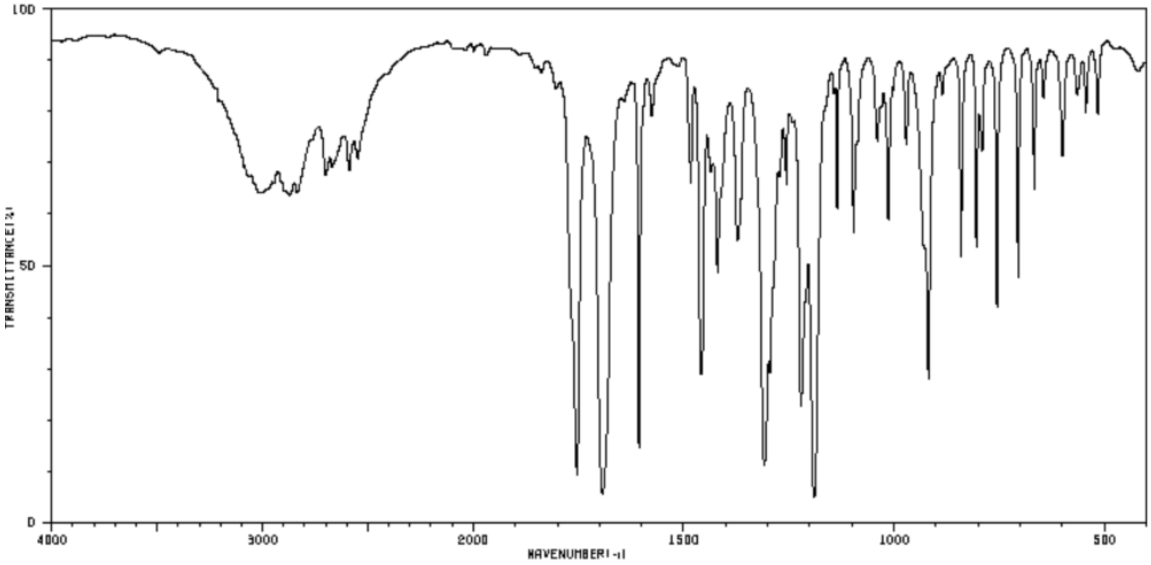
(c) On both NMR spectra, assign as many peaks as you can by numbering the peaks from left to right, drawing Unknown X in the box provided, and labeling each carbon or hydrogen atom with the appropriate peak number. For atoms that cannot be assigned with certainty, list the signals to which they might reasonably correspond.

(d) Label any important peaks on the IR, clearly identifying which bond(s) correspond(s) to each peak.

**Unknown X:**

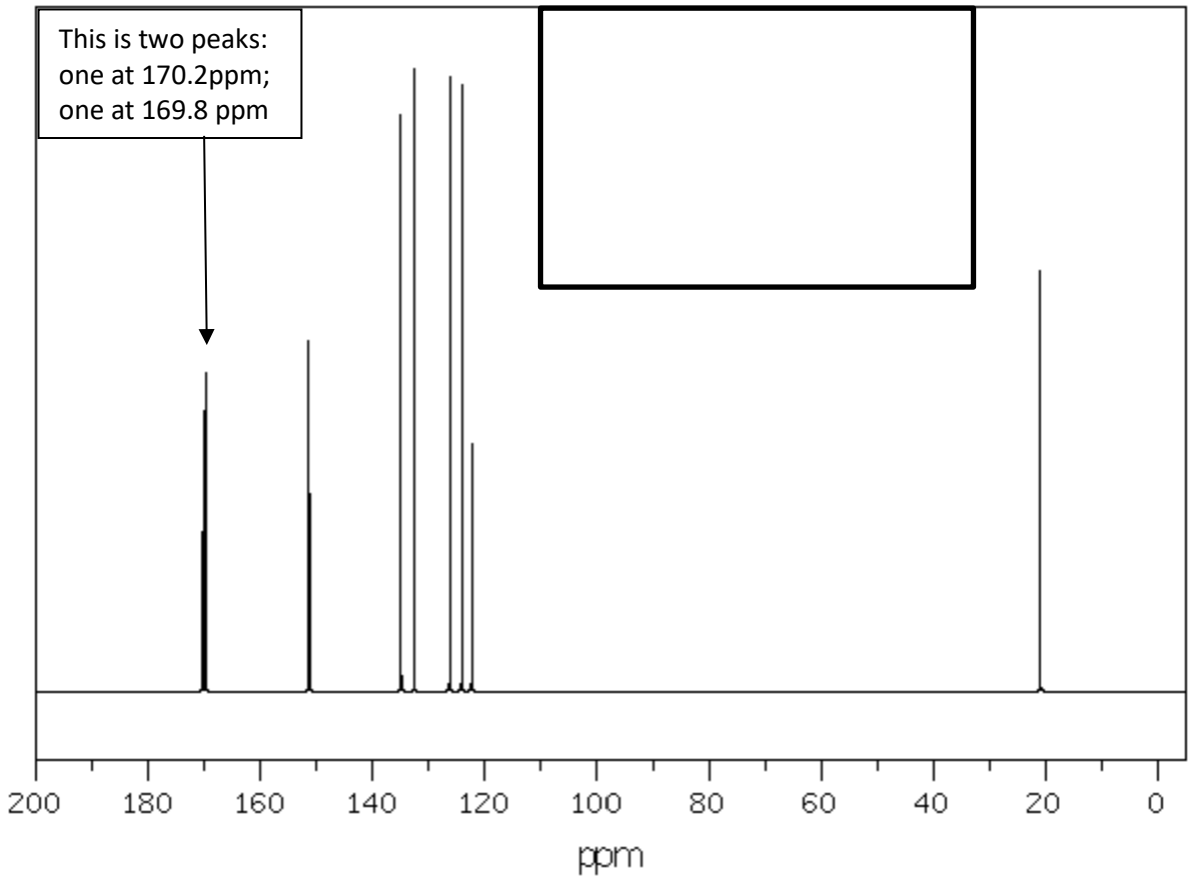
8. *…continued*

## $C_9H_8O_4$



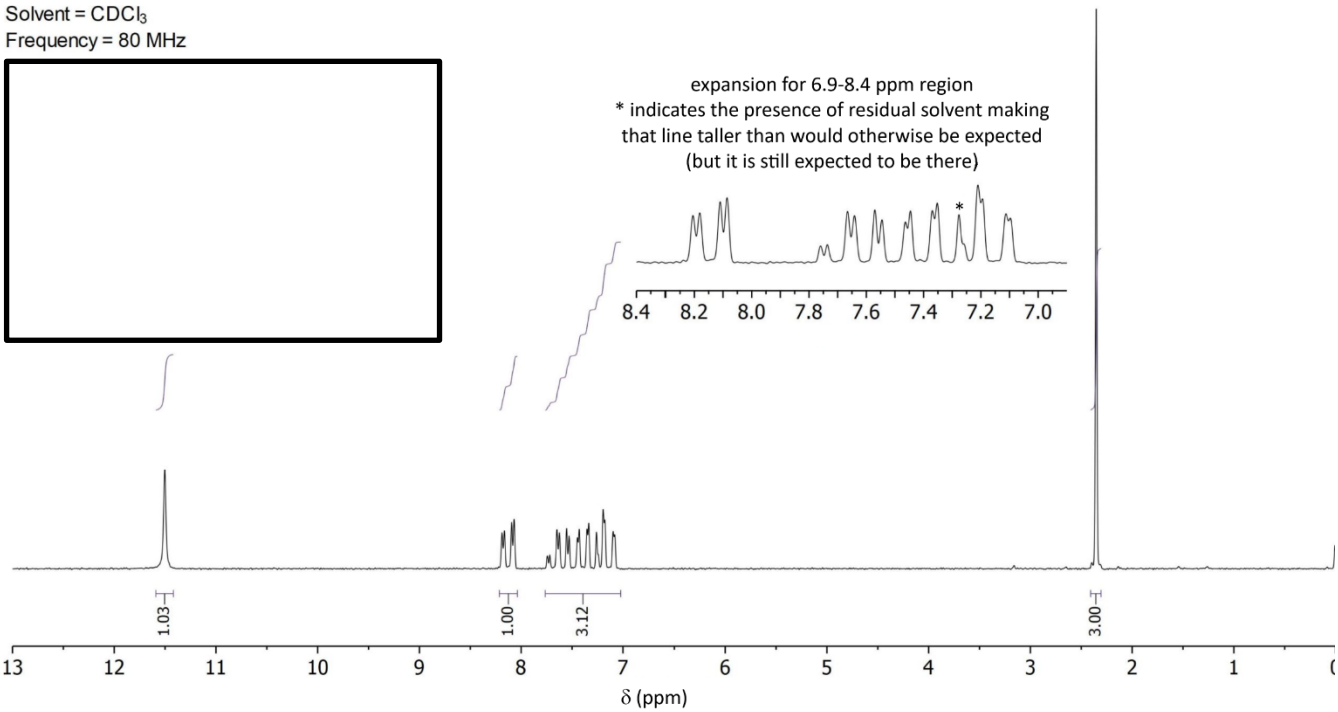

**Some Longer Peaks**

| | |
|---|---|
| 3006 $cm^{-1}$ | 62% |
| 2983 $cm^{-1}$ | 62% |
| 2891 $cm^{-1}$ | 62% |
| 2824 $cm^{-1}$ | 62% |
| 2701 $cm^{-1}$ | 66% |
| 2548 $cm^{-1}$ | 66% |
| 1754 $cm^{-1}$ | 8% |
| 1693 $cm^{-1}$ | 6% |
| 1606 $cm^{-1}$ | 16% |



8. *…continued*

$C_9H_8O_4$




*An answer worth full marks will assign every peak on the $^1H$ NMR spectrum to a specific hydrogen atom or set of equivalent hydrogen atoms.*

9. Of the four spectroscopic techniques discussed in CHEM 2600 (IR, $^{1}H$ NMR, $^{13}C$ NMR and MS), which would be the most effective if you needed to distinguish between a bottle of chlorobenzene and a bottle of bromobenzene whose labels had both fallen off? Briefly explain which peak(s) would be most distinctive for each compound and where on each spectrum you would expect to see them. Be specific. **[5 marks]**

10. What was the most useful and/or interesting thing you learned in CHEM 2600? **[1 mark]**

**…AND THAT'S ALL FOR CHEM 2600.**

**HAVE A GREAT SUMMER!**