**CHEM 234**

**PRINTED FIRST NAME**  
**PRINTED LAST NAME**  
**ASU ID or Posting ID**

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**Person on your LEFT (or Aisle)**

- **PRINT YOUR NAME ON EACH PAGE!**
- **READ THE DIRECTIONS CAREFULLY!**
- **USE BLANK PAGES AS SCRATCH PAPER**
  - work on blank pages will not be graded...
- **WRITE CLEARLY!**
- **MOLECULAR MODELS ARE ALLOWED**
- **DO NOT USE RED INK**
- **DON'T CHEAT, USE COMMON SENSE!**

Extra Credit_____/5  
Total (incl Extra)________/175+5

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**Person on your RIGHT (or Aisle)**

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**THIS IS A CHM 234 PRACTICE EXAM**

**MIDTERM #3 PRACTICE TEST #1**

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**Interaction Energies, kcal/mol**

<table>
<thead>
<tr>
<th>Eclipsing</th>
<th>Gauche</th>
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</thead>
<tbody>
<tr>
<td>H/Me -1.0</td>
<td>He/Me -0.9</td>
</tr>
<tr>
<td>H/Me -1.4</td>
<td>Et/Me -0.95</td>
</tr>
<tr>
<td>Me/Me -2.6</td>
<td>i-Pr/Me -1.1</td>
</tr>
<tr>
<td>Me/Me -2.9</td>
<td>t-Bu/Me -2.7</td>
</tr>
</tbody>
</table>

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**Infrared Correlation Chart**

**Approximate Coupling Constants, J (Hz), for $^1H$ NMR Spectra**

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**NMR Correlation Charts**

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**Note:** The image contains chemical structures, diagrams, and tables related to chemical bonding and interactions, along with practice test instructions and guidelines. It is a practice exam for CHM 234, specifically the third midterm practice test with practice test #1.
Question 1  Give the IUPAC name for the following compounds. Be sure to use cis/trans, E/Z or R/S where appropriate.

\[ \text{(5R)-hydroxyhex-(3E)-enal} \]

Question 2  Rank in order of increasing equilibrium constant for formation of an acetal with a brief explanation. Draw the expected acetal for one of the reactions (only), it does not matter which one.

\[ \begin{align*}
A & & \text{MeOH} \\
& & \text{H}^+ \text{(cat.)} \\
B & & \text{MeOH} \\
& & \text{H}^+ \text{(cat.)} \\
C & & \text{MeOH} \\
& & \text{H}^+ \text{(cat.)}
\end{align*} \]

\[ \text{___ < ___ < ___} \]

(lowest  highest)

Question 3  Give the alkyl bromide and the carbonyl compound you would use to synthesize the following alkene in a Wittig synthesis and show all steps and reagents/conditions.

\[ \text{Ph} \]

\[ \text{deleted} \]
Question 4 For each reaction

a) Provide the missing reagents/conditions or major organic products as appropriate, pay attention to stereochemistry including racemic mixtures unless specified

b) Unless otherwise indicated.....

State whether the OVERALL reaction is Addition, Elimination, Substitution or Rearrangement

State whether the reaction is oxidation, reduction or neither

Briefly explain whether the a solution of the product would be optically active or not

---

### a)

\[
\begin{align*}
\text{Zn(Hg)} & \\
\text{HCl, H}_2\text{O} & \\
\end{align*}
\]

---

### b)

\[
\begin{align*}
\text{1 Equiv. (CH}_3\text{)}_2\text{NH} & \\
\text{HCl (cat.)} & \\
\end{align*}
\]

ignore stereochemistry/optical activity
ignore oxidation/reduction
ignore addition/elimination etc.

---

### c)

\[
\begin{align*}
\text{Na}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4 & \\
\end{align*}
\]

ignore stereochemistry/optical activity
ignore addition/elimination etc.

---

### d)

\[
\begin{align*}
\text{CO/HCl} & \\
\text{AlCl}_3 & \\
\end{align*}
\]

ignore stereochemistry/optical activity
ignore oxidation/reduction etc.

---

### e)

\[
\begin{align*}
\text{H}_3\text{O}^+ & \\
\end{align*}
\]

ignore stereochemistry/optical activity
ignore oxidation/reduction
ignore addition/elimination etc.
Question 5  Draw the complete arrow pushing mechanism for the following reaction. Indicate the Lewis acid/base at each step, and if they are also Bronsted acids bases. Add non-bonding electrons as necessary. Draw the ALL important resonance structure of the intermediates.

\[
\begin{align*}
\text{O} & \quad \text{NH} \\
\text{H}_3\text{N} & \quad \text{H}_2\text{N} \\
\text{H} & \quad \text{OTs} \\
\text{O} & \quad \text{H}_2\text{N} \\
\text{H} & \quad \text{HTsO} \\
\text{O} & \quad \text{H}_2\text{N} \\
\text{H} & \quad \text{OTs} \\
\text{O} & \quad \text{H}_2\text{N} \\
\text{H} & \quad \text{HTsO} \\
\end{align*}
\]

Question 6  Rank the following in terms of increasing rate of reaction with PhMgBr. Give a BRIEF explanation and NAME the three functional groups.

\[
\begin{align*}
\text{\_\_} & \quad < \quad \text{\_\_} & \quad < \quad \text{\_\_}
\end{align*}
\]
Question 7  Show how you would make the target molecules from the provided starting structures. Show all intermediate structures, do not show any mechanisms.

a)  

b)
Question 2. For the Bronsted acid/base reaction below:
   a) Give the curved arrow-pushing in both directions
   b) Draw a reaction energy diagram and include a drawing of the transition state
   c) Label the acids/bases and which are stronger and give a brief explanation
   d) Indicate which reaction is faster (left to right or vica versa) and on which side the equilibrium lies and which acid has the smaller and which the larger pKa

\[ \text{ Produto fornecido } \]

Question 5. The purpose of this question is to determine whether the provided product is allowed or forbidden

1) draw the arrow-pushing that describes formation of the PROVIDED product
2) How many electrons are involved in the reaction?
3) FOR THE PROVIDED PRODUCT (which may or may not be allowed), would the ring closing be disrotatory or conrotatory?
4) FOR THE PROVIDED PRODUCT (which may or may not be allowed), would the transition state be Hückel or Möbius?
5) Is PROVIDED PRODUCT allowed or forbidden and why?
Question 1 Give the IUPAC name for the following compound. Be sure to use cis/trans, E/Z or R/S where appropriate.

\[
\text{5-hydroxy-4-methylhept-(4E)-en-6-ynal}
\]

Question 2 Rank the following in terms of increasing rate of electrophilic aromatic substitution, e.g., reaction with HNO₃/H₂SO₄. Give a BRIEF explanation.

A has 2 D/activating groups and 2 W/deactivating groups,
B has 3 D/activating groups and 1 W/deactivating group,
C has 4 D/activating groups,
C is thus fastest in electrophilic aromatic substitution.

\[
\text{H₃O}^+ \text{ cleave the 2 single bonds indicated by the dashed lines}
\]

Question 3 Give the product of complete acid catalyzed hydrolysis of the following structure.

\[
\text{deleted}
\]
Question 4  For each reaction
a) Provide the missing reagents/conditions or major organic products as appropriate, pay attention to stereochemistry including racemic mixtures unless specified

a) \[
\text{Ph-} \xrightarrow{\text{MgBr}} \text{C=O}
\]

b) \[
\text{MeO-} \xrightarrow{1. \text{Cl}} \text{AlCl}_3 \xrightarrow{2. \text{Zn/Hg/HCl/H}_2\text{O}} \text{PhCHO}
\]

c) \[
\text{PhCHO} \xrightarrow{\text{CH}_3\text{OH}} \text{PhCH}_2\text{CH}_2\text{OH}
\]

d) \[
\text{cyclohexane CO} \xrightarrow{} \text{cyclohexyl-NMe}_2
\]

e) \[
\text{deleted} \xrightarrow{} \text{Ph-CH}_2\text{CH}_3
\]
Question 5  Give a full curved arrow-pushing mechanism for the following reactions, show where every proton goes to and comes from (no +H^+/-H^+) and indicate the Lewis and Bronsted acids/bases at each intermolecular step, include important resonance contributors for all intermediates, give the number of steps in your mechanism.

a)

\[
\begin{array}{c}
\text{HCl/H}_2\text{O} \\
\xrightarrow{\text{HCl/H}_2\text{O}} \\
\text{H}_2\text{O} \\
\end{array}
\]

b)

\[
\begin{array}{c}
\text{NaOH/H}_2\text{O} \\
\xrightarrow{\text{NaOH/H}_2\text{O}} \\
\end{array}
\]
Question 6. Show how you would synthesize the target compounds on the right from the starting compounds on the left. Show reagents and conditions, and the structures of important intermediate compounds. Do not show any (arrow pushing) mechanisms.

a)  

\[
\begin{align*}
\text{Br}_2, h\nu & \quad \text{BrMg} \\
\text{HO} & \quad \text{O} \\
\text{H}_3\text{O}^+ & \quad \text{Mg} \cdot \text{THF}
\end{align*}
\]

\[
\begin{align*}
\text{Br} & \quad \text{BrMg} \\
\text{O} & \quad \text{O} \\
\text{OH} & \quad \text{OH} \\
\text{HBr/ROOR} & \quad \text{Mg.THF} \\
\text{1.} & \quad \text{H}^+ \text{cat. (not } \text{H}_3\text{O}^+) \\
\text{2. } & \quad \text{H}_3\text{O}^+ \\
\text{NaBH}_4/\text{EtOH}
\end{align*}
\]
Question 6) The ylide below undergoes an electrocyclic ring closure reaction

\[ \text{t-Bu} \rightleftharpoons \text{H} \rightleftharpoons \text{t-Bu} \]

\[ \Delta \]

a) give the curved arrow-pushing that accounts for product formation
b) draw the product, paying special attention to relative stereochemistry of any substituents
c) indicate the locations of any chiral (asymmetric) carbons atoms with the \( \text{S} \) symbol, and state whether it is racemic, a meso compound or achiral
d) give the NUMBER of electrons involved in the reaction
e) state whether the allowed reaction proceeds via a Huckel or a Mobius transition state
f) state whether the allowed reaction proceeds via a conrotatory or a disrotatory ring closing

The reaction is antarafacial on the lower reactant because the cis-stereochemistry of the substituents becomes trans- in the product (this would not be included as part of the answer)

Question 9) Classify the following structures as aromatic, non-aromatic or anti-aromatic, assume all structures are as flat as possible, AND give the number of electrons involved in the conjugated system

- Benzene: aromatic, 4 electrons
- Benzene: aromatic, 4 electrons
- Heterocyclic: anti-aromatic, 8 electrons
- Aromatic system: aromatic, 4 electrons
- Anti-aromatic system: anti-aromatic, 8 electrons
Question 1
Give the IUPAC name for the following compound. Be sure to use cis/trans, E/Z or R/S where appropriate.

\[ \text{OH} \]
\[ \text{O} \]
\[ \text{OH} \]
\[ \text{OH} \]

Question 2.
Give a complete curved arrow pushing mechanism, and...
1) Indicate the Lewis acid/Lewis base (LA, LB) at each step as appropriate, and whether they are also Brønsted acids/bases (LA/BA, LB/BB), show where every proton comes from and goes to (no +H+/-H+).
2) GIVE THE NUMBER OF STEPS IN YOUR MECHANISM

\[ \text{HCl} \]
\[ \text{O} \]
\[ \text{OH} \]
\[ \text{OH} \]

Question 3)
Classify the following structures as aromatic, non-aromatic or anti-aromatic, assume all structures are as flat as possible, AND give the number of electrons involved in the conjugated system.

\[ \text{aromatic} \]
\[ \text{6 electrons} \]
\[ \text{these electrons} \]
\[ \text{are in sp}^2 \text{ hybrid A.O.s} \]
Question 3  For each reaction
1) Provide the missing reagents/conditions or major organic products as appropriate

a) \[
\begin{align*}
\text{Ph} & \quad \rightarrow & \quad \text{H}_3\text{O}^+
\end{align*}
\]

b) \[
\begin{align*}
\text{Br} & \quad \rightarrow & \quad \text{H}_3\text{O}^+ \\
\text{CO/}\text{HCl} & \quad \rightarrow & \quad \text{AlCl}_3
\end{align*}
\]

c) \[
\begin{align*}
\text{Ph} & \quad \rightarrow & \quad \text{H}_3\text{O}^+
\end{align*}
\]

d) \[
\begin{align*}
deleted
\end{align*}
\]

2. \(\text{BuLi}\)
3. \(\text{O} \quad \text{H}\)

\(\text{PPh}_3\)

\(1 \quad \text{Equiv.} \quad \text{TsOH (cat.)}\)

\(\text{ignore stereochemistry}\)
Question 4  Rank the following in terms of increasing frequency of carbonyl stretching vibration in an IR spectrum. To solve this problem you will need to draw minor resonance contributors and remember that stronger bonds vibrate with higher frequency.

\[
\begin{align*}
\text{A} & : H_3C\equiv C\equiv H \\
\text{B} & : H_3C\equiv C\equiv NMe_2 \\
\text{C} & : H_3C\equiv C\equiv \text{CH}_3
\end{align*}
\]

The more the minor resonance structure contributes to the overall structure, the more the C=O bond has single bond character, the lower the vibrational frequency.

Question 5  Give the product of the following reaction. Remember that D represents deuterium, an isotope of hydrogen, that is used to keep track of where hydrogen atoms go in chemical reactions. We did not cover this reaction class, but you should be able to work it out based on what you know about the mechanisms of these reduction reactions.

\[
\begin{align*}
\text{CH}_3\text{CH}_3\text{C} & \equiv \text{C} = \text{N} \\
& \xrightarrow{1. \text{LiAlH}_4} \text{CH}_3\text{CH}_3\text{C} \equiv \text{C} = \text{N} \\
& \xrightarrow{2. \text{D}_3\text{O}^+} \text{CH}_3\text{CH}_3\text{C} \equiv \text{C} = \text{N}
\end{align*}
\]

Question 9) The structure below undergoes an electrocyclic ring opening reaction (remember, D means deuterium, an isotope of hydrogen that is often used as a labelled hydrogen atom)

\[
\begin{align*}
\text{D} & \equiv \text{D} \\
& \xrightarrow{\Delta} \text{D} \equiv \text{D}
\end{align*}
\]

a) give the curved arrow-pushing that accounts for product formation
b) draw the product, paying special attention to relative stereochemistry of any substituents
c) give the NUMBER of electrons involved in the reaction
d) state whether the allowed reaction proceeds via a Huckel or a Mobius transition state
e) state whether the allowed reaction proceeds via a conrotatory or a disrotatory ring closing
Question 6. Show how you would synthesize the target compounds on the right from the starting compounds on the left. Show reagents and conditions, and the structures of important intermediate compounds. Do not show any (arrow pushing) mechanisms.

a) 

b)
Question 7  Give a full curved arrow-pushing mechanism for the following reactions, show where every proton goes to and comes from (no +H/−H) and indicate the Lewis and Bronsted acids/bases at each intermolecular step, include important resonance contributors for all intermediates, give the number of steps in your mechanism.

\[
\text{cytosine is one of the pyrimidine bases in DNA, it can be converted into uracil, if this happens this can be a damage mechanism that could lead to mutation. Assume that this reaction occurs via the usual acid catalyzed mechanisms that we study in class, give a mechanism for formation of uracil from the provided tautomer of cytosine.}
\]
Question 1  Give the IUPAC name for the following compound. Be sure to use cis/trans, E/Z or R/S where appropriate.

\[
\text{3-butyl-4-methyl-5-oxo-hex-(3E)-enal}
\]

Question 2  Rank the following in order of increasing equilibrium constant for formation of a hydrate. Give a BRIEF explanation:

\[
\begin{align*}
\text{A} & : \text{O}^+ \text{C}^+ \text{H}_3 \text{O}^- \\
\text{B} & : \text{O}^+ \text{C}^+ \text{O}_2 \text{N}^- \\
\text{C} & : \text{O}^+ \text{C}^+ \\
\text{____} & < \text{____} < \text{____}
\end{align*}
\]

The reaction is addition of a weak nucleophile to the C=O group, A is least reactive since it has a strong donating group that can stabilize the carbonyl carbon via resonance, B has a withdrawing group that destabilizes the carbonyl carbon.

Question 3.  Rank in order of increasing rate of reaction with −CN, give a BRIEF explanation:

\[
\begin{align*}
\text{A} & : \text{O}^+ \text{C}^+ \text{H}_3 \text{C}^- \\
\text{B} & : \text{O}^+ \text{C}^+ \text{O}^+ \\
\text{C} & : \text{O}^+ \text{F}^+ \text{F}^- \\
\text{(fastest)} & < \text{____} < \text{____} \text{ (slowest)}
\end{align*}
\]

B has donating group (oxygen) adjacent to the C=O, decreases reactivity towards nucleophilic attack, C has two electronegative groups adjacent to the C=O, increasing reactivity towards nucleophilic attack.
Question 4. For each reaction:
1) Provide the missing reagents/conditions or major organic products as appropriate
2) Pay attention to stereochemistry including racemic mixtures unless specified

a) 

b) 

KOH/heat

N$_2$H$_4$

Br$_2$ / FeBr

d) 

(CH$_3$)$_2$NH

H$^+$ cat.

e) 

H$_3$O$^+$
Question 5. Show how you would synthesize the target compound on the right from the starting compound on the left. Show reagents and conditions, and the structures of important intermediate compounds. Do not show any (arrow pushing) mechanisms.

a) 

b)
Question 6  Give a full curved arrow-pushing mechanism for the following reactions, show where every proton goes to and comes from (no $\text{H}^+/-\text{H}^+$) and indicate the Lewis and Bronsted acids/bases at each intermolecular step, include important resonance contributors for all intermediates, give the number of steps in your mechanism.

a)  

![Chemical structure](image)

$\text{H}_3\text{O}^+ 

b)  

![Chemical structure](image)

$\text{H}_3\text{O}^+$
Question 7  Rank in order of increasing rate of reaction with a Grignard reagent, give a brief explanation in terms of nucleophiles and electrophile strength and the factors that control these in this context.

\[ \text{In these reactions the Grignard is the Lewis base and the carbonyls are the Lewis acid, the stronger the Lewis acid the faster the reaction.} \]

\[ \text{the carbonyl carbon in D has two weak donating -CH}_3\text{ groups attached, which decreases the electrophilicity, this reaction is slower than A (one donating group) which is slower than B (zero donating groups)} \]

\[ \text{C is fastest of all, the -CF}_3\text{ is electron withdrawing, which increases the electrophilicity of the carbonyl carbon.} \]

\[ \begin{align*}
\text{A} & \quad \text{H}_3\text{C} & \quad \text{H} \\
\text{B} & \quad \text{H} & \quad \text{H} \\
\text{C} & \quad \text{F}_3\text{C} & \quad \text{H} \\
\text{D} & \quad \text{H}_3\text{C} & \quad \text{CH}_3 \\
\end{align*} \]

\[ \text{___ < ___ < ___ < ___} \]

Question 8.  Rank in order of increasing rate of electrophilic aromatic substitution at the carbons indicated by the arrows. Give a BRIEF explanation.

\[ \text{Reaction at both A and C is faster than at B and D, because both are activated by strong (amine) and weak (aryl) donating groups on the ring. Reaction at A is activated more than at C because the strongest donating group activates more. Reaction at B and D is deactivated by the strongly withdrawing nitrile group, but D is deactivated more than at C.} \]