Final Examination


Write your name here: 

Sign your name here: 

Instructions:

1. This examination package contains 19 questions and 16 pages. It is your responsibility to check that there are no pages missing.
2. Fill in your name before answering the questions.
3. Answer ALL questions in the space provided.
4. Answer the questions in ink and do not use liquid white or correction tape, otherwise, your right to contest your grade will be compromised.
5. Write CLEARLY, messy answers will not be marked.
6. Do not detach any of the sheets in this booklet.
7. Please note that NON-PROGRAMMABLE CALCULATORS and MOLECULAR MODELS are permitted but cannot be passed around.
8. Whenever required, structural formulae must be shown complete.
9. Your attention is drawn to the college policy on cheating. This policy will be enforced.

Marking Scheme:

1. ___/12  
2. ___/6   
3. ___/4   
4. ___/5   
5. ___/6   
6. ___/2   
7. ___/4   
8. ___/5   
9. ___/9   
10. ___/1  
11. ___/7  
12. ___/4  
13. ___/4  
14. ___/5  
15. ___/6  
16. ___/4  
17. ___/10 
18. ___/2  
19. ___/4  

TOTAL ___/100  
TOTAL ___/40
1. Give IUPAC names for the following compounds. Include R/S & E/Z nomenclature where necessary. (2 pts each, total 12 pts)

a. 3-methyl-4-hepten-1-ol

b. m-nitrotoluene

c. \((R)-2\text{-cyclopropyl-4-octyne}\)
   The cyclopropyl has higher priority because it has CH attached to chiral C. Others are \(-\text{CH}_2-\) and \(-\text{CH}_3\)

d. \((2R,4R)-2\text{-chloro-4-fluoro-hexane}\)

e. \((3R,1S)-1\text{-t-butyl-3-methyl-cyclohexane}\)

f. \(E-2\text{-bromo-2-pentene}\)
2.
   a. Draw the Newman projection formulas of the most stable conformation and the least stable conformation of butane, along the C2-C3 bond. (2 pts)

   ![Newman projection formulas of butane]

   **most stable**

   **least stable**

   b. For the least stable conformation, the relative positions of the two methyl groups is best described as **eclipsed**. (1 pt)

   c. Which of the following corresponds to the potential energy diagram for the rotation about the C2-C3 bond of butane? (1 pt)

   Answer: [A]

   ![Potential energy diagrams]

   d. List two reasons responsible for making the least stable conformation higher in energy. (2 pts)

   Torsional strain exists when the dihedral angle is not 60°. Torsional strain exists in ethane. In addition, when the H's in ethane are replaced by alkyl groups, then steric strain due to Van der Waals repulsion occurs.
3. Draw the mechanism to account for the given product using curved arrows. (4 pts)

\[
\text{+ HCl} \quad \rightarrow \quad \text{Cl} \\
\]

4. a. Draw the mechanism to account for the given products using curved arrows. (4 pts)

\[
\text{+ HCl} \quad \rightarrow \quad \text{products} \\
\]

b. Which product, A or B, is the major product of the above reaction under these conditions? (1 pt)

Answer: B 1,2 addin preferred at least
a. Draw the mechanism of the reaction below. Use the Br-Br$^+$-FeBr$_3$ as the electrophile. Show all resonance structures of the carbocation (arenium ion) intermediate. (4 pts)

b. Draw the resonance structures of the carbocation intermediate that would lead to the meta product. Use these structures to explain why the meta product is not formed to any significant quantities. (2 pts)
6. Arrange the following substrates in order of their increasing $S_N2$ reactivity with NaCN. (2 pts)

\[ \text{3}^{\circ} \quad \text{Cl} \quad \text{A} \quad \text{slowest} \]

steric crowding in 5-member trans phase

\[ \text{1}^{\circ} \quad \text{Cl} \quad \text{B} \quad \text{fastest} \]

\[ \text{Cl} \quad \text{C} \]

7. Draw the mechanism which accounts for the formation of the major organic product, when the two compounds are allowed to react. Draw in 3D when necessary. Use curved arrow notation. Draw and indicate clearly the structure of the major product. (4 pts)

\[ \text{loss of HCl on C}_5 - \text{C}_6 \]

not a good conformer. t-Bu should be in equatorial position.

axial becomes equatorial et vice versa.

note only $H_A$ and $Cl_A$ are antiperiplanar

major product. (loss of HCl only)
8. Show the required reagents to synthesize the following compounds: Mechanisms are not required. Give the final product in the last box. (5 pts)
9. Show the required steps to synthesize the following compounds. Show all intermediate products. Use any inorganic and organic reagents necessary. Mechanisms are not required. (9 pts)

a.

b.
10. Explain why the following reaction does not occur. (1 pt)

Does not work, \textit{OH} is a strong base and a poor leaving group.
11. Give the structural formulae of all possible monobromination products for the following reaction. Circle the major product. (3 pts)

\[ \text{Br}_2 \xrightarrow{h\nu} \]

b. Draw a mechanism for the production of the 2° alkyl halide. (4 pts)

1. Chain Initiation: \( \text{Br}^{-} + \text{Br}^{+} \rightarrow 2 \text{Br}^{-} \)

2. A. \[ \text{X} \text{Y} + \text{Br}^{-} \rightarrow \text{X} \text{Y} + \text{HBr} \]

B. \[ \text{X} \text{Y} + \text{Br}^{-} \rightarrow \text{X} \text{Y} + \text{Br}^{-} \]

Used in 2A
12. The compounds below have the pK_a values 4.7, 16, 45, and 62. Insert the correct pK_a value in the box for each compound. (4 pts)

\[\begin{array}{c|c}
\text{H}_2\text{C} & \text{45} \\
\text{H}_3\text{C} & \text{62} \\
\text{H}_3\text{C} & \text{4.7} \\
\text{H}_3\text{C} & \text{16} \\
\end{array}\]

13. Which of the two compounds has a higher boiling point? Explain. (4 pts)

a. CH₃CH₂-O-CH₂CH₃ or CH₃CH₂-O-H

\(\text{H} \text{ bonding}\)  \\
\(\text{H} \text{ bonding}\)

\(\text{no H} \text{ bonding}\)  \\
\(\text{weaker dipole-dipole interactions}\)

b. More branched \\
Less surface area. \\
Less branched \\
More surface area \\
Stronger Van der Waals \\
higher B.P.
14. a. Draw the 3D formulae of the products of the following reaction. (4 pts)

\[
\text{Br must be anti-coplanar}
\text{Two possibilities}
\]

b. Will the final solution be optically active? (1 pt)

\[
\text{No it is a racemic mixture}
\]

15. Give the structures of significant organic products. For each reaction, indicate in the box whether the major mechanism is \( S_N1 \), \( S_N2 \), \( E1 \), or \( E2 \). (2 pts each, total 6 pts)

a) \[
\begin{align*}
\text{Br} & \quad \text{CH}_3 \\
\text{CH}_3 & \quad \text{CH}_3 \\
\text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

b) \[
\begin{align*}
\text{hindered base, won't SUB} & \quad \text{Cu}_2
\end{align*}
\]

c) \[
\begin{align*}
\text{SN1 - racemization} & \quad \text{Cu}_3 \quad \text{I} + \quad \text{I} \quad \text{C}_3H_7
\end{align*}
\]
16. What is the relationship between the following molecules? Place your answer in the box. (4 pts)

i. enantiomers
ii. diastereomers
iii. constitutional isomers
iv. same molecule
v. none of the above

a. [Diagrams of molecules]

b. [Diagram showing mirror image and "same"

(c. [Diagrams of molecules]

(d. [Diagrams of molecules]
17. Give the structural formulas of the significant organic products for the following reactions. For the reactions with more than one significant organic product, circle the major product. Include stereochemistry where applicable. (2 pts each, total 10 pts)

a) 

\[ \text{[Structural formula]} \]

b) 

\[ \text{[Structural formula]} \]

\[ \text{anti Markovnikov add' n HBr} \]

c) 

\[ \text{[Structural formula]} \]

\[ \text{[Structural formula]} \]

\[ \text{H adds here so one gets a benzyl cation (shrink ring)} \]

d) 

\[ \text{[Structural formula]} \]

\[ \text{trans alkene} \]

e) 

\[ \text{[Structural formula]} \]

\[ \text{[Structural formula]} \]

\[ \text{Cl} \]
18. When subjected to ozonolysis, followed by treatment with zinc and water, compound A (C₅H₆) gives the following products: (2 pts)

\[ A \xrightarrow{1) \text{O}_3} \overset{2) \text{Zn, H₂O}}{\text{H} = \text{C} \quad \text{O} \quad \text{H} = \text{C} \quad \text{O}} + \overset{\text{H} \quad \text{C} \quad \text{H} \quad \text{C} \quad \text{H}}{\text{O} \quad \text{C} \quad \text{H}} \]

What is the structure of compound A?

19. List the following in order of increasing stability. (4 pts)

a. 1-octene
b. 1,2-dimethylcyclohexene
c. 3-methylpent-2-ene
d. (E)-2-heptene

e. (Z)-2-heptene

\[ \text{a} \quad \text{e} \quad \text{d} \quad \text{c} \quad \text{b} \]

Least

Highest

Which of the above compounds will release the most energy upon hydrogenation? \[ \text{a} \]
# Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Main Groups</th>
<th>Periodic Table</th>
<th>Main Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 IA</td>
<td>Hydrogen</td>
<td>18 VIIIa</td>
</tr>
<tr>
<td>2 IIA</td>
<td>Helium</td>
<td></td>
</tr>
<tr>
<td>3 Li Be</td>
<td>Lithium</td>
<td>19 B C N O F</td>
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<td></td>
<td></td>
<td>20 Ne</td>
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<td>4 Na Mg</td>
<td>Sodium</td>
<td>21 Al Si P S</td>
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<td></td>
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<td>22 Cl Ar</td>
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<td>5 K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr</td>
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<td>23 Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Tl Pb Bi Po At Rn</td>
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<td></td>
<td>Potassium</td>
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</tr>
<tr>
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<td>25 Cs Ba <strong>La</strong> Hf Ta W Re Os Ir Pt Au Hg Ti Pb Bl Po At Rn</td>
<td></td>
</tr>
<tr>
<td>7 Cs Ba <strong>La</strong> Hf Ta W Re Os Ir Pt Au Hg Ti Pb Bl Po At Rn</td>
<td>26 Fr Ra <em>Ac</em>*</td>
<td>27 Ra <em>Ac</em>*</td>
</tr>
<tr>
<td>8 Fr Ra <em>Ac</em>*</td>
<td>28 Lu Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr</td>
<td>29 Lr Law</td>
</tr>
</tbody>
</table>

*Main-Group elements are also called Representative Elements.*