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. 

b. 

c. 

d. 

e. 

f. 

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)

b. For the least stable conformation, the relative positions of the two methyl groups is best described as __________________. (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: ☐

   ![Energy vs Angle of Rotation Diagram]

   A  B  C

   Energy  Angle of rotation

   d. List two reasons responsible for making the least stable conformation higher in energy. (2 pts)
3. Draw the mechanism to account for the given product using curved arrows. (4 pts)

\[
\begin{align*}
\text{ } & \quad \text{HCl} \\
\downarrow & \quad \downarrow \\
\text{ } & \quad \text{Cl}
\end{align*}
\]

4.

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

\[
\begin{align*}
\text{ } & \quad \text{HCl} \quad -70^\circ \text{C} \\
\downarrow & \quad \downarrow \\
A & \quad B
\end{align*}
\]

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

Answer: □
5.

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)

\[ \text{aryl-CH}_3 \rightarrow \text{aryl-CH}_3 \]

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)

\[ \text{slowest} \quad \text{fastest} \]

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)
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)

\[
\text{HO-} \text{alkane-} \cdot \cdot \cdot \cdot \cdot \cdot \text{Na}^+ \quad \times \quad \text{cyclic compound}
\]
11.

a. Give the structural formulae of all possible monobromination products for the following reaction. Circle the major product. (3 pts)

\[
\begin{array}{c}
\text{Br}_2 \\
\hline
hv
\end{array}
\]

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

\[ \begin{align*}
&\text{H}_2\text{C}==\text{CH}_2 \\
&\text{H}_3\text{C}==\text{CH}_3 \\
&\text{O} \\
&\text{H}_2\text{C}==\text{C}==\text{OH} \\
&\text{H}_3\text{C}==\text{H}_2\text{OH} \\
&\text{pK}_a
\end{align*} \]

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

a. CH_3CH_2-O-CH_2CH_3 or CH_3CH_2-O-H

b. 

or
14.  
   a. Draw the 3D formulae of the products of the following reaction. (4 pts)

   ![Chemical structure](image)

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

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)
   ![Chemical structure](image)

   b)
   ![Chemical structure](image)

   c)
   ![Chemical structure](image)
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. 

b. 

c. 

d. 
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) 
\[
\text{Br} \quad + \quad \text{CH}_3\text{CH}_3\text{CH}_3\text{CH}_3
\]

b) 
\[
\text{H}_3\text{C} + \text{HBr} \quad \text{HOOH} \rightarrow
\]

c) 
\[
\text{H}_3\text{C} = \text{C} = \text{CH}_3 + \text{HBr} \rightarrow
\]

d) 
\[
\text{H}_3\text{C} - \text{C} = \text{C} - \text{CH}_3 \quad \text{NH}_3 \quad \text{Na} \rightarrow
\]

e) 
\[
\text{HO} \quad \text{HCl} \rightarrow
\]
18. When subjected to ozonolysis, followed by treatment with zinc and water, compound A (C₃H₆) gives the following products: (2 pts)

\[
A \xrightarrow{1) \text{O}_3} \xrightarrow{2) \text{Zn, H}_2\text{O}} \text{O} \quad \begin{array}{c}
\text{O} \\
\text{HC} \quad \text{CH}
\end{array} + \begin{array}{c}
\text{O} \\
\text{HC} \quad \text{C} \quad \text{CH}
\end{array}
\]

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

Which of the above compounds will release the most energy upon hydrogenation?
# Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Main Groups</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1IA</td>
<td>p block elements</td>
</tr>
<tr>
<td>2IA</td>
<td>18 VIA</td>
</tr>
<tr>
<td>11IIIA</td>
<td>15VIA</td>
</tr>
<tr>
<td>12IIIB</td>
<td>16VIIA</td>
</tr>
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<td>18VIIIA</td>
</tr>
<tr>
<td>14IVA</td>
<td></td>
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<td></td>
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<td>17VIIA</td>
<td>18VI</td>
</tr>
</tbody>
</table>

### Main Groups
- **1IA**
  - **Hydrogen** (1, 1.0079)
- **2IA**
  - **Helium** (2, 4.0026)
- **3IIIA**
  - **Lithium** (3, 6.944)
- **4IIIA**
  - **Sodium** (11, 22.989)
- **5IIIA**
  - **Potassium** (19, 39.982)
- **6IIIA**
  - **Rubidium** (55, 85.468)
- **7IIIA**
  - **Cesium** (87, 132.91)
- **8IIIA**
  - **Francium** (223, 258)

### p block elements
- **1S**
  - **Hydrogen** (1, 1.0079)
- **2S**
  - **Helium** (2, 4.0026)
- **3S**
  - **Lithium** (3, 6.944)
- **4S**
  - **Sodium** (11, 22.989)
- **5S**
  - **Potassium** (19, 39.982)
- **6S**
  - **Rubidium** (55, 85.468)
- **7S**
  - **Cesium** (87, 132.91)
- **8S**
  - **Francium** (223, 258)

### d block elements
- **11IIIB**
  - **Scandium** (21, 45.941)
- **12IIIB**
  - **Titanium** (22, 47.867)
- **13IIIB**
  - **Vanadium** (23, 50.942)
- **14IIIB**
  - **Chromium** (24, 52.00)
- **15IIIB**
  - **Manganese** (25, 54.938)
- **16IIIB**
  - **Iron** (26, 55.847)
- **17IIIB**
  - **Cobalt** (27, 58.933)
- **18IIIB**
  - **Nickel** (28, 58.713)
- **19IIIB**
  - **Copper** (29, 63.546)
- **20IIIB**
  - **Zinc** (30, 65.38)

### f block elements
- **31IIIA**
  - **Gallium** (31, 69.722)
- **32IIIA**
  - **Germanium** (32, 72.64)
- **33IIIA**
  - **Arsenic** (33, 74.92)
- **34IIIA**
  - **Selenium** (34, 79.904)
- **35IIIA**
  - **Bromine** (35, 80.91)
- **36IIIA**
  - **Krypton** (36, 83.798)

### Lanthanide Series
- **58IIIA**
  - **Lanthanum** (57, 138.91)
- **59IIIA**
  - **Actinium** (227, 227)

### Actinide Series
- **90IVA**
  - **Thorium** (232, 232.04)
- **91IVA**
  - **Protoactinium** (233, 233.04)

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