Person on your LEFT (or Aisle) | Person on your RIGHT (or Aisle)
--- | ---
1 | 9
2 | 10
3 | 11
4 | 12
5 | 13
6 | 14
7 | 18
8 | 63

Extra Credit | Total (incl Extra)
--- | ---
0 | 375

Interaction Energies, kcal/mol

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

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

- **Aromatic Ar**
- **Alkyl**
- **Aldehydes**
- **Amides**
- **Alcohols**
- **Amines**
- **Nitro-compounds**

**Infrared Correlation Chart**

- **O-H**, **C=O**, **N-H**, **N=O**
- **O=C-O-H**
- **C=C**

**NMR Correlation Charts**

- **OCH**
- **OCH**
- **H-C-X**
- **H2C-NR2**
- **Alkyl**

**Variable and Condition-Dependent**

- **Aromatic Ar**
- **Aldehydes**
- **Amides**
- **Alcohols**
- **Amines**
- **Nitro-compounds**

**Chem 233, Fall 2014**

**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!**

**Printed First Name**
**Printed Last Name**
**ASU ID or Posting ID**
Question 1 (15 pts.) Give the IUPAC name for the following. Specify stereochemistry as appropriate.

Question 2 (18 pts.) Give the product of the following Lewis acid/base reaction. Indicate the Lewis/base and whether they are also Bronsted acids/bases, give the curved arrow pushing showing bond making/breaking and BRIEFLY explain why the reactions would be exothermic or endothermic.

Question 3 (10 pts.) For the following cyclohexane, draw the lowest energy chair conformation (only)

Question 4 (16 pts.) Give the Lewis structure for (2R)-bromo-(3R)-methylpentane, with stereochemistry indicated using wedged/dashed bonds as appropriate, AND, draw a Lewis structure of its enantiomer (clearly indicate which structure is which)
Question 5 (44 pts) Solvolysis of both bromides A and B form the same ether, as shown below

a) Draw a full -curved arrow-pushing mechanism for each reaction, at each intermolecular step indicate the Lewis acid and base and whether they are also Bronsted acids and bases. Include all reasonable resonance contributors for intermediates as appropriate.

b) Draw a properly labelled reaction energy diagram for BOTH reactions on the SAME diagram, CLEARLY indicate which diagram refers to which reaction

CLEARLY INDICATE THE ACTIVATION ENERGY FOR THE RATE DETERMINING STEP FOR EACH REACTION

c) BRIEFLY explain which reaction would be faster, A or B
Question 6 (16 pts.)
1. Determine whether the following structures are identical, enantiomers or diastereomers.
2. Identify any meso compounds.
3. Give the absolute configuration at each chiral (asymmetric) center.

![Chemical structures]

Question 7 (22 pts.) For the following two reactions
a) give the curved arrow pushing showing bond making/breaking and indicate the Lewis acids/bases (LA/LB) and whether they are also Bronsted acids/bases (BA/BB).

b) one of these reactions is endothermic, the other is exothermic, indicate which is which and give a brief explanation for WHY each reaction is exothermic or endothermic.

![Chemical reactions]

Question 8 (24 pts.)
a) Draw pictures of the wavefunctions of the molecular orbitals requested, on the molecules. In each case indicate the A.O.'s used to make the M.O.'s.

![Molecular orbitals]

C-O \( \pi \) orbital
C-C \( \sigma \) orbital indicated by the arrow
O-H \( \sigma^* \) orbital
Question 9 (70 pts.) Give the missing major ORGANIC PRODUCT for each reaction

a) Show all stereochemistry as appropriate, identify any MESO compounds
b) Briefly explain whether and why a solution of the product would be optically active or not
c) assign each reaction as addition, elimination, substitution or rearrangement

a)  
\[
\begin{align*}
\text{Cl} & \quad \xrightarrow{\text{CH}_3\text{O}^- + \text{Na}} \quad \text{DMF} \\
\end{align*}
\]

b)  
\[
\begin{align*}
& \quad \xrightarrow{\text{HBr}} \\
\end{align*}
\]

c)  
\[
\begin{align*}
& \quad \xrightarrow{\text{HBr}} \quad \text{ROOR} \\
\end{align*}
\]

d)  
\[
\begin{align*}
& \quad \xrightarrow{1. \text{BH}_3\text{THF}} \quad \text{2. } \text{-OH/H}_2\text{O}_2 \\
\end{align*}
\]

e)  
\[
\begin{align*}
& \quad \xrightarrow{\text{H}_2} \quad \text{Pd/C} \\
\end{align*}
\]

f)  
\[
\begin{align*}
& \quad \xrightarrow{\text{Br}_2} \quad \text{hv} \\
\end{align*}
\]

g)  
\[
\begin{align*}
& \quad \xrightarrow{\text{Br}_2} \quad \text{MeOH (solvent)} \\
\end{align*}
\]
Question 10 (32 pts). For nucleophiles going down the periodic table, nucleophilicity and basicity follow exactly the same trend in polar APROTIC solvents, but follow OPPOSITE trends in polar PROTIC solvents. Use this information to answer the following questions.

a) Draw a reaction energy diagram for BOTH reactions A and B on the SAME diagram, clearly indicate BOTH activation energies AND both reaction exothermicities. Explain which reaction would be faster (both reactions are exothermic because the tosylate anion \( \text{OTs}^- \) is very stable, and ignore the Hammond postulate).

\[
\begin{align*}
\text{A} & \quad \text{DMF} \quad \text{Na}^+ \text{Cl}^- \quad \begin{array}{c}
\text{OTs}^- \quad \text{C} \quad \text{Br}^- \quad \text{C}\quad \text{Cl}^- \quad + \quad \text{Na}^+ \text{OTs}^- \\
\end{array} \\
\text{B} & \quad \text{DMF} \quad \text{Na}^+ \text{Br}^- \quad \begin{array}{c}
\text{OTs}^- \quad \text{C} \quad \text{Br}^- \quad \text{C}\quad \text{Br}^- \quad + \quad \text{Na}^+ \text{OTs}^- \\
\end{array}
\end{align*}
\]

b) Now do the same for reactions C and D below, and explain why the nucleophilicities are different in polar protic versus polar aprotic solvents (both reactions are exothermic and again ignore the Hammond postulate).

\[
\begin{align*}
\text{C} & \quad \text{MeOH} \quad \text{Na}^+ \text{Cl}^- \quad \begin{array}{c}
\text{OTs}^- \quad \text{C} \quad \text{Br}^- \quad \text{C}\quad \text{Cl}^- \quad + \quad \text{Na}^+ \text{OTs}^- \\
\end{array} \\
\text{D} & \quad \text{MeOH} \quad \text{Na}^+ \text{Br}^- \quad \begin{array}{c}
\text{OTs}^- \quad \text{C} \quad \text{Br}^- \quad \text{C}\quad \text{Br}^- \quad + \quad \text{Na}^+ \text{OTs}^- \\
\end{array}
\end{align*}
\]
Question 11 (38 pts.)

a) For the reaction shown, give a curved arrow mechanism and indicate the Lewis/Bronsted acids and bases at each step as appropriate, and indicate the number of steps and transition states associated with your mechanism.

b) Draw a reaction energy diagram, indicate the positions and relative energies of the starting materials, intermediates and products and ALL TRANSITION STATES, but Do not draw the structures of any transition states.

c) On your diagram, indicate the activation energy for each step in the mechanism and the reaction exothermicity and clearly indicate the rate determining step.
Question 12 (28 pts.)

a) Rank the three indicated C–H bonds A, B and C in order of increasing bond dissociation energy. Draw an energy diagram for cleavage of all THREE bonds and give a BRIEF explanation for your choice of ranking.

\[
\begin{array}{ccc}
\text{lowest} & < & \text{highest} \\
\text{BDE} & < & \text{BDE}
\end{array}
\]

![Energy Diagram](image)

b) For the structure below, give the curved arrow pushing and the products of homolytic cleavage for the C–H bond that has been added to the line-angle structure (include all resonance contributors as appropriate).

![Structure](image)

Question 13 (14 pts.)

Give the hybridization of the NITROGEN atom in acetonitrile (structure given below), and show that you understand the meaning of the hybridization assignment by making a small table that summarizes all of the valence hybrid (and any unhybridized) atomic orbitals associated with this nitrogen atom, and state how they are used (e.g. used to make a sigma bond to the chlorine, I know there is no chlorine in the structure, this is just to show you what do to).

\[
\begin{align*}
\text{H}_3\text{C} & \equiv \text{C} \equiv \text{N} : \\
\text{H}_3\text{C} & \equiv \text{C} \equiv \text{N} : \\
\end{align*}
\]

Extra Credit (5 pts.) Which of the following drugs resulted in terrible birth defects in Europe in the 1960s?

- ibuprofen
- thalidomide
- ketamine
- thebaine
Question 14 (28 pts) Provided are spectra for a compound with molecular formula $C_6H_{12}O_2$

a) Give the degrees of unsaturation ________________

b) On the infrared spectrum, indicate the peaks that identify the functional groups in the molecule (including C(sp$^3$)-H). Indicate BOTH the functional group, and where appropriate, the specific BOND in the functional that corresponds to the peak.

[Infrared spectrum image]

2856
2997
959
1109
1198
1381
1461
1729

2H quartet
3H triplet
6H doublet
1H multiplet

C) Draw the structure and clearly indicate which hydrogens correspond to which signals in the proton nmr spectrum (only)

[Proton NMR spectrum image]