Information

Date: Thursday, October 11, 2017
Location: Meet in the lab, 340 SHC
Time: 11:00 a.m. Exam is written for 2 hours.

Policies

1. Each student must present a valid Oakton or state photo ID to obtain an exam. Pictures on the ID must be clearly visible and not excessively worn or degraded.

2. You are required to write your name and your Banner ID at the top of each side of each page. Failure to follow these instructions will result in the loss points listed on each side of each page in the exam. You will not be allowed to complete this when time is called. This should be done at the beginning of the exam.

3. The only electronic device that may be used on the exam is a handheld standard calculator. Programmable calculators and graphing calculators are **NOT** allowed. These electronic devices also may **NOT** be used during the exam: cell phones, iPhones, any iDevice, PDA's, iPod's, laptops, earphones or any other device that is not a standard, non-programmable calculator.

4. Exam answer must be legible for full credit. It is recommended that you use a pencil so that corrections can be made. Illegible, difficult to read answers will be marked incorrect.

Format and Content

The format of the exam will closely resemble homework, quizzes, clicker questions and skillbuilder exercises:

Ranking (10 questions):	20 pts
Short Answer and Essay (15-20 questions):	80 pts
Total:	**100 pts**

Study Guide

Ranking (10 questions; 20 points)
The following are examples of potential ranking questions on the exam.
- Rank each bold carbon atom in order of increasing chemical shift (1 = lowest chemical shift, 5 = highest chemical shift).
- Rank each circled bond in order of increasing wavenumber (frequency) in infrared spectroscopy (1 = lowest wavenumber; 5 = highest wavenumber).
- Rank in order of increasing index of hydrogen deficiency (1 = lowest IHD, 5 = highest IHD).
- Rank in order of increasing number of signals in the 1H-NMR (1 = fewest signals; 5 = most signals).

- Rank each pair of reactants in order of increasing *net* reactivity (i.e., increasing reaction rate) to provide an alkyl halide product (1 = slowest reaction/least reactive, 5 = fastest reaction/most reactive).
- Rank in order of increasing boiling point (1 = lowest boiling point, 5 = highest boiling point).
- Rank in order of polarizability.
- Rank in order of 1H-NMR chemical shift.

Short Answer and Essay (15 questions; 80 points)

The following are potential short answer questions/topics. This list is not exhaustive, just a guide. The questions will be similar in format to those found on homework and quizzes.

- **First**, draw the splitting tree for each coupling that would provide the ^{1}H-NMR signal shown. **Second**, label each *J*-value in the splitting tree (e.g., $\leftarrow J_1 \rightarrow$). **Third**, calculate each *J*-value. Show all work for credit.
- **First**, list whether each pair of H-atoms indicated is homotopic, enantiotopic, diastereotopic or heterotopic. **Second**, list how many signals you'd expect to see in the ^{1}H and ^{13}C-NMR spectra.
- **Match** NMR spectra to isomeric molecules. **Match** IR spectra to molecules.
- **First**, sketch the 1H-NMR you would expect to see for the following molecule. Your sketch should include the chemical shift scale (with values), signals (no signals should overlap) and multiplicity where appropriate. Circle each equivalent set of protons in the molecule and then label them with lowercase letter. Label each of your drawn signals with those letters. **Second**, sketch the IR spectrum you would expect to see for this molecule. Your sketch should include the wavenumber scale (with values) and the bands for each bond type in the molecule. Label each band with its corresponding bond (e.g., C=O).
- Identify the molecules represented by the IR, NMR and MS below. For partial credit, explain how you arrived at your structure.
- Draw a specific example of each functional group.
- Provide IUPAC names for each molecule (alkanes, alkyl halides, alcohols, rings).
- Determine the enthalpy of a reaction from a table of bond dissociation energies (BDE).
- Describe three factors that effect NMR chemical shift.
- Explain why IR C-H stretching occurs at higher IR frequencies for sp2-hybridized carbons compared to sp3.
- List two factors that effect IR intensity. List two factors that effect IR frequency.
- Calculate the coupling constant (J-value) for the doublet, triplet, quartet, doublet of doublets, etc. below.
- Explain how mass spectrometry can identify benzyl fragments, bromine atoms and chlorine atoms.
- Draw the product of each substitution reaction below.
- Match the IR spectra to the molecules listed. Each molecule may only be used once.
- Match the NMR spectra to the molecules listed. Each molecule may only be used once.
- Briefly explain what is meant by "resonance frequency" and how this relates to precession.
- Calculate the relative percentages of each parent peak in an isotopic cluster for molecules with: 1 chorine atom, 2 chlorine atoms, 1 bromine atom, 2 bromine atoms, 1 chlorine and 1 bromine atom, etc.
- Determine the number of carbon atoms in an unknown from its mass spectrum
- Determine the total number of stereoisomers possible from the number of chirality centers and E/Z alkenes
- Calculate the enantiomeric excess
- Use optical rotation to determine the percentage of two enantiomers in solution
- Calculate specific optical rotation
- Use Malus's law to determine optical rotation of a solution
- Classify pairs of molecules as identical, not isomers, enantiomers, conformers, diastereomers, or constitutional isomers.
- Determine the total numbers of H and C signals expected for the molecules below.
- Classify each pair of hydrogens indicated as homotopic, enantiotopic, diastereotopic or heterotopic.

- Describe how you could construct and use a homemade polarimeter. What materials would you need? How would it operate?
- Draw enantiomers of molecules.
- Draw splitting trees for doublet, triplet, quartet, doublet of doublet, etc.
- Determine the ratio of peak heights in common multiplicities
- Use a reaction coordinate diagram to characterize the spontaneity, enthalpy, equilibrium constant and rate of reactions.
- Write a rate law for a chemical reaction.
- List the variables that affect the rate of a reaction.
- Define the variables in the Arrhenius equation
- Explain what is meant by transition state theory and how it relate to the Arrhenius equation.
- Draw a complete mechanism for an SN1 reaction.
- Draw the transitions states for each elementary step in an SN1 and SN2 reaction
- Explain the difference between SN1 and SN2
- Draw the structure of a carbocation
- Rank carbocations in order of relative stability.
- Explain why tertiary carbocations are more stable the secondary which are more stable the primary, etc.