Midterm II Review Packet

Part A: Multiple Choice and Matching (12 questions)

1. Which of the following IR spectras contains an amine? Select all that apply

   a. 
   ![Graph A]
   
   b. 
   ![Graph B]
c.

ANSWER: A and C

Spectra A contains a primary amine. Primary amines give stretches in IR from 3200-3500cm^-1 as two peaks.

Spectra C contains a secondary amine. Secondary amines give a stretch in IR from 3000-3300cm^-1 as a singular peak.

d.

ANSWER: A and C

Spectra A contains a primary amine. Primary amines give stretches in IR from 3200-3500cm^-1 as two peaks.

Spectra C contains a secondary amine. Secondary amines give a stretch in IR from 3000-3300cm^-1 as a singular peak.
2. Which of the following descriptions best fit the IR spectra of a carboxylic acid? Select all that apply

a. A medium intensity band at 2250 cm\(^{-1}\)
b. A strong and broad intensity band at 2500-3500 cm\(^{-1}\)
c. A medium intensity band at 3500-3300 cm\(^{-1}\)
d. A strong intensity band at 1710 cm\(^{-1}\)

ANSWER: B and D

The following spectra displays a carboxylic acid. Notice the components; we have a C=O and an -OH. C=O (carbonyls) characteristically appear as a strong intense band at 1710 cm\(^{-1}\). The OH of the carboxylic acid won’t look like a normal -OH in IR. In a carboxylic acid, the -OH stretch is so broad that it almost obscures the C-H peaks at 3000 cm\(^{-1}\)
3. Match the following molecules to their respective IR spectras.

- Compound A
- Compound B
- Compound C

Spectra 1:

Spectra 2:
ANSWER: When tackling problems like this, you first need to see what distinguishes one molecule from the others. We know IR spectra tell us about functional groups, so ensure to identify what groups are different in one molecule vs another.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>IR Spectra</th>
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<tbody>
<tr>
<td><img src="image" alt="Molecule" /></td>
<td><img src="image" alt="Spectra 2" /></td>
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</table>

This molecule is an aldehyde, and although it can be difficult to know how this molecule differs from the others, specifically how it differentiates from the ketone (molecule 3). The big give away here is we have an Csp2-H stretch. Csp2-H stretches from an aldehyde appear at...
2700-2830 cm\(^{-1}\) and have a medium intensity, and that’s exactly what we see in this IR spectra.

This molecule has a nitrile. We know nitriles appear at 2250 cm\(^{-1}\) and have a medium intensity.

This molecule is a ketone, and we can distinguish it from the others in that it has a C=O stretch and a Csp\(^3\)-H stretch. We know it can’t be spectra 2 because spectra 2 has traces of Csp\(^2\)-H carbons. In general, C=O stretches are sharp and appear at 1700 cm\(^{-1}\), but depending on the type of carbonyl, (i.e. ketone, aldehyde, ester, etc.) they can have different, distinct, and discreet stretches in the 1700-1800 cm\(^{-1}\) region - also a differentiating factor!
Additionally, Csp3-H stretches are strong and appear at 2850-3000 cm^-1.

4. What is the correct IUPAC name for the following molecule?

4-sec-butyl-5-tert-butyl-6-ethyl-7-sec-butyl-2-methyldecane

ANSWER:

a. 5-(sec-butyl)-6-(tert-butyl)-7-ethyl-2-methyldecane
b. 6-(sec-butyl)-5-(tert-butyl)-4-ethyl-9-methyldecane
c. 6-(tert-butyl)-5-(sec-butyl)-2-methyl-7-ethyldecane
d. 6-(tert-butyl)-5-(sec-butyl)-4-ethyl-9-methyldecane
First find the longest chain, in this case it’s the decane highlighted in red. Then name the substituent groups and number them in a way that leads to the lowest numbered position for all substituents. When those are found, simply order the substituents alphabetically.

5. Match the correct substituent butyl group to its name (some names may be used more than once).

<table>
<thead>
<tr>
<th>Name</th>
<th>Butyl Substituent Group</th>
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<tbody>
<tr>
<td></td>
<td><img src="image1" alt="Butane" /></td>
</tr>
<tr>
<td></td>
<td><img src="image2" alt="Isobutyl" /></td>
</tr>
<tr>
<td></td>
<td><img src="image3" alt="Sec-butyl" /></td>
</tr>
<tr>
<td></td>
<td><img src="image4" alt="Tert-butyl" /></td>
</tr>
<tr>
<td></td>
<td><img src="image5" alt="n-butyl" /></td>
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</tbody>
</table>

Word Bank: Butane, Isobutyl, Sec-butyl, Tert-butyl, n-butyl,

**ANSWER:**
### Name | Butyl Substituent Group
--- | ---
**Butane** | ![Butane Newman Projection]
**Tert-butyl** | ![Tert-butyl Newman Projection]
**Sec-butyl** | ![Sec-butyl Newman Projection]
**Isobutyl** | ![Isobutyl Newman Projection]
**Sec-butyl** | ![Sec-butyl Newman Projection]
**n-butyl** | ![n-butyl Newman Projection]

6. Rank the following Newman projections in order of increasing energy.
First, identify all the types of strain present in each molecule. Off the bat, we know an eclipsed conformation has higher conformational energy compared to the staggered conformation, due to eclipsed conformations having both steric and torsional strain from overlap.

When comparing A, B, and D, consider steric strain. We know steric strain is higher when two large substituent groups are closer together. With this logic, we see molecule B and A both have ethyl groups in close proximity to each other. In D, the ethyl groups are on opposite sides of the molecule. This means D will be lowest in energy.

Comparing B and A, look at the location of methyl, in B, methyl is further away from the two ethyl groups, meaning B will have less steric strain compared to A.

Therefore, increasing energy is as follows: D, B, A, C

7. Which of the following is an accurate depiction of a chair conformation for the following cyclohexane? (select all that apply)
When tackling problems like this, draw out the chair conformation of the cyclohexane and then draw the chair flipped version.

How to convert cyclohexane to chair:

First, know that substituents on a wedge are above the ring plane, while substituents on a dash are below the ring plane. Meaning, when we draw out these substitutions, we must respect the stereochemistry and draw the substituents on wedges upwards, and the substituents on dashes downwards.

When converting the normal depiction of a cyclohexane into its chair conformation, you can really start counting anywhere, but be sure to keep the pattern and direction in which you count consistent.

If you wanted, you could have numbered clockwise instead of counter clockwise, but whatever you do, be sure to stay consistent. Also it’s crucial to note that since the question asks for the most stable chair conformation, know that equatorial positions are more stable than axial positions due to avoiding 1,3-diaxial steric interactions. So draw the chair in a way that as many of the substituents as possible are in the equatorial position.
How to do a ring flip:

To perform a ring-flip, first number your initial cyclohexane (in the chair conformation). Then begin drawing out the “flipped” version of your initial cyclohexane, and when you draw that out, draw it in a way that it looks like the mirror image of the initial ring as seen below:

Then start numbering your “flipped” cyclohexane by moving the numbers that were used to label your initial cyclohexane clockwise. The image below will better depict what I’m describing:

Notice how the carbon is numbered in molecule “A”, then notice that when we flip it, the numbers shifted by one carbon but did so in the clockwise direction.

And know whenever you perform a ring flip, groups on the axial position will now become equatorial. Likewise, any group that was equatorial will now become axial. And groups in the up position will stay up, while groups in the down position will stay down. So the only thing that will change is the equatorial bonds during the ring flip.

When deciding on which of the chairs are more stable, think about which position on the cyclohexane is more stable, and we know the equatorial position is more stable as the equatorial position minimizes steric repulsion. So that means, the chair conformation with more non-hydrogen groups on the equatorial position will be more stable, as seen in the answer.
8. What is the correct structure for (3R,5S,6R)-5-ethyl-3,6-dimethylnonane?

ANSWER: A

When solving this problem, I recommend to first draw out the base molecule with no stereochemistry, so draw out 5-ethyl-3,6-dimethylnonane.

Once you draw it out, start assigning the stereochemistry. To assign R and S configuration, rank each group on a stereogenic center from highest to lowest priority, with highest priority being numbered as 1, and the lowest being numbered as 4. We know a group has higher priority if it has a higher atomic number, for instance, oxygen has a higher atomic number than hydrogen, meaning it’s prioritized first. And in situations where the atomic number is equivalent, say there are two carbons attached to a stereocenter, look and see if those carbons are attached to anything else. For instance, if we compared a methyl group to an ethyl group, the ethyl group would have higher priority than the methyl.

Once you're done assigning priority, consider the direction in which highest to lowest priority goes. If it goes clockwise, it’s R configuration, if it goes counter-clockwise, it’s S configuration. And finally, consider where your lowest and highest priority groups are. If your highest is on a wedge, keep configuration as is. If your lowest priority is on a wedge, flip the configuration.
9. What is the relationship between these two compounds?

- a. Enantiomers
- b. Diastereomers
- c. Neither
- d. Constitutional Isomers

ANSWER: B

Know that diastereomers are stereoisomers that are not mirror images. We can identify them easily by assigning R and S configurations, because a diastereomer will have one or more different configurations at one or more of the equivalent stereocenters.

When we assign R and S configuration for the following molecules, this is what we get:

See how they differ at the stereocenter that has a Cl, therefore, this is a diastereomer.
10. How many stereogenic centers are there in the following molecule?

A. 5
B. 4
C. 7
D. 8

ANSWER: B

To look for stereogenic centers, look for carbons with 4 unique groups.
11. Which of the following molecules are meso?

a. 

b. 

c. 

ANSWER: A 

Meso compounds have an internal line of symmetry. It can be hard to see, but rotate the molecule so that the carbonyls are pointing in the same way. When you do that, you’ll notice the molecule does have an internal line of symmetry, and it’ll look something like this.
12. Walter White synthesizes (-)-methamphetamine, and measured its ee as 91%, what is the ratio of (-)-methamphetamine to the (+)-methamphetamine in the sample?

a. 91% L and 9% R  
b. 45.5% L and 45.5% R  
c. 95.5% L and 4.5% R  
d. 70% L and 4.5% R  

The formula for ee is ee = L - R / L + R, but truthfully, you don’t need any complicated formulas to solve this.

Here is a shortcut to solve problems like this:

We see that (-)-methamphetamine has an ee of 91%. Take the difference between the ee given and 100%

Step 1: 100% - 91% = 9%

Now, take that difference, and divide it in half

Step 2: 9% / 2 = 4.5%

Since the EE given was for (-)-methamphetamine, take that number you just got, and add 4.5 to it like so:

Step 3: 91% + 4.5% = 95.5%.

And so that’s the answer for our (-)-methamphetamine or levorotatory enantiomer.

To now find the (+)-methamphetamine, it’s just the 4.5% we solved for in step 2.

So our answer is 95.5% L and 4.5% R

If the question was different and gave you ee for (+)-methamphetamine, or the dextrorotatory enantiomer, do the same steps, but now the levorotatory enantiomer will be the answer of step 2, and the dextrorotatory enantiomer will be the answer of step 3.
Part B: Free Response Questions

World renowned music critic Anthony Fantano is writing a review for a new album, the album cover is as follows:

Answer the questions about the cyclohexane in the album cover

1a. Write the IUPAC name of the compound

1b. Draw two chair conformations for the compound, and circle the higher energy chair conformation

1c. Draw the structure of the enantiomer for the compound
ANSWER:

1a. (1S-3R)-3-bromo-1-butyl-chlorocyclohexane

Ensure to assign R and S configuration, and know in an IUPAC name, they go in front of the name, as seen above. R and S priority is shown below.

1b.

1c.
The DEA busted the notorious Heisneberg and captured his supply of a new mystery compound. Unfortunately, they have no clue what this compound is, but they did find the name of the compound which is meso-4,5-dibromooctane

2a. Draw the Newman projection of the most stable conformation about the bond between carbons 4 and 5 of meso-4,5-dibromooctane.

2b. Is the molecule drawn in 2a chiral?

2c. Draw one diastereomer of meso-4,5-dibromooctane

2d. Is the molecule in 2c chiral?

ANSWER:

2a. I recommend drawing out the molecule as a straight alkane chain first, then convert it to the Newman projection. Notice the Newman projection is staggered, and the large substituent groups are as far away from each other as possible, making this the most stable form.
2b. No, this molecule is NOT chiral. A chiral molecule is not-super imposable on its mirror image.

2c. A diastereomer will differ in one or more stereogenic centers.

2d. Yes, the molecule in 2c is chiral. You cannot superimpose molecule 2c with its mirror image.