First Midterm – CHM1321-B

Professor Sandro Gambarotta

Date:_15 February 2018 Length:__80 min_____ Last Name: _____

First Name:_____

Student #_____

- **Instructions:**
  - **Calculator permitted (Faculty approved or any other non-programmable kind)**
  - **Molecular Model Kit strongly encouraged**
  - **Closed book exam**
  - **Periodic table allowed**

Cellular phones, unauthorized electronic devices or course notes (unless an open-book exam) are not allowed during this exam. Phones and devices must be turned off and put away in your bag. Do not keep them in your possession, such as in your pockets. If caught with such a device or document, the following may occur: you will be asked to leave immediately the exam, academic fraud allegations will be filed which may result in you obtaining a 0 (zero) for the exam.

Read carefully:

By signing below, you acknowledge that you have read and ensured that you are complying with the above statement.

Signature:_____

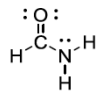
Question 1 (2 points)

In formamide, CH_3NO, the N, O, and one H atom are bound to the carbon atom, while the other two H atoms are bonded to the N atom.

a) Draw a complete Lewis structure of formamide, in which all valence atomic orbitals are filled and no atom bears a formal charge.

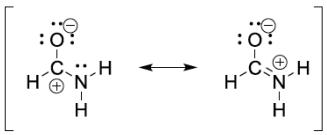
b) Formamide can be drawn using two other possible Lewis structures that are resonance forms of the molecule. Draw these Lewis structures.

a) Lewis structure of formamide with filled valence atomic orbitals and formal charge:



formamide

b) Formamide resonance forms:



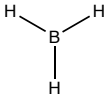
Question 2 (1 point)

a) Boron lies one position to the left of carbon in the periodic table. Based on this information, how many valence electrons does boron have?

b) Borane, BH_3, is an important reagent in organic chemistry. Draw its Lewis structure and predict its shape.

c) Based on its shape, assign a hybridization to the boron atom of borane. What is the total number of electrons in the valence orbitals of the boron atom due to sharing with its three neighbours?

a) 3



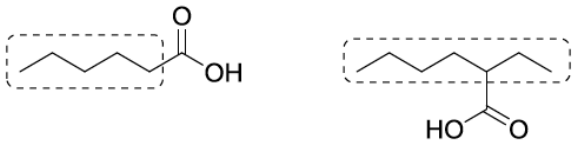
b) Trigonal planar,

c) sp^2 6 electrons

Question 3 (1 point)

The boiling point of $CH_3(CH_2)_4CO_2H$ is 206 °C. Do you expect the boiling point of 2-ethylhexanoic acid to be higher or lower than this? Provide an explanation for your choice.

The intermolecular forces would involve hydrogen bonding from the carboxylic acid groups. This would be similar for both molecules. The only difference would be in the dispersion forces between the hydrocarbon chains. Line drawings of both would look like:

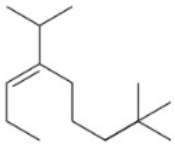


The alkane region in 2-ethylhexanoic acid is seven carbons long, while it is only five in hexanoic acid. This would result in more attractions in 2-ethylhexanoic acid and, therefore, 2-ethylhexanoic acid should have a higher boiling point.

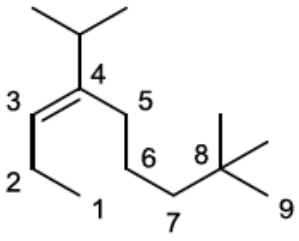
Question 4 (1 point)

Name the following unsaturated hydrocarbons.

a)



a)



8,8-dimethyl-4-(2-propyl)non-3-ene

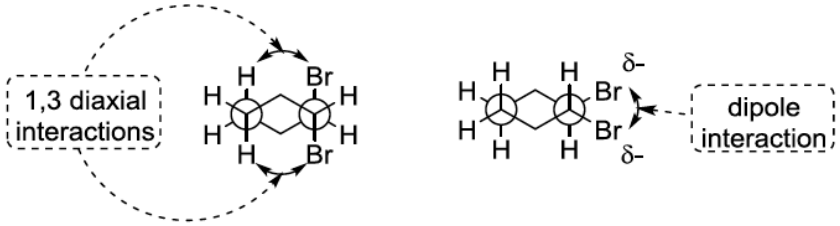
But also acceptable are

8,8-dimethyl-4-(isopropyl)non-3-ene and 8,8-dimethyl-4-(1-methylethyl)non-3-ene

Question 5 (3 points)

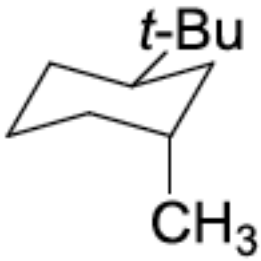
Sighting along the C-1–C-2 (and C-5–C-4) bond, draw the two chair conformations of *trans*-1,2-dibromocyclohexane in Newman projection and identify the sources of strain in each chair conformation.

The axial bromines interact with axial hydrogens in the form on the left. The equatorial bromine atoms are polarized and will repel each other due to like charges in the form on the right. Also, the large size of the bromine atom would add to the steric strain in the equatorial orientation.



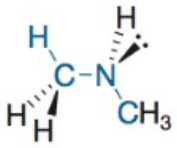
Question 6 (2 points)

Draw the chair conformation of *trans*-1-*tert*-butyl-3-methylcyclohexane in which the methyl substituent is positioned axially.



Question 7 (3 points)

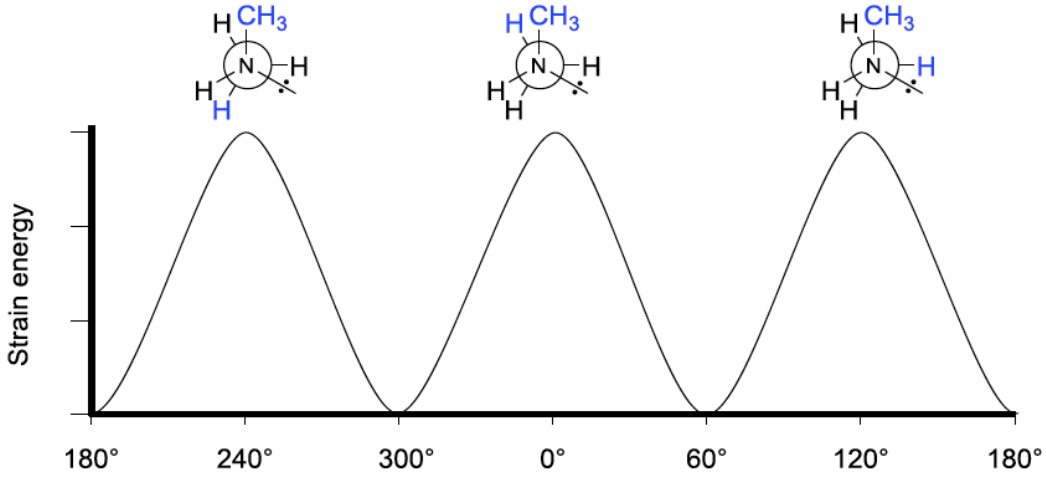
a) Sighting along its C–N bond, draw the Newman projection of the conformation of dimethylamine given in perspective below. (Note the presence of the lone pair of electrons on the nitrogen.)



b) Qualitatively plot a graph of strain energy vs. torsion angle for a full 360° rotation about this C–N bond. Define the torsion angle by the two C atoms, one N atom, and one H atom of dimethylamine as shown above in blue.

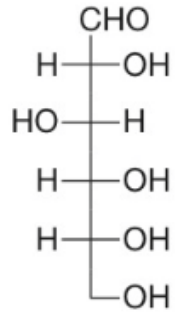
a)

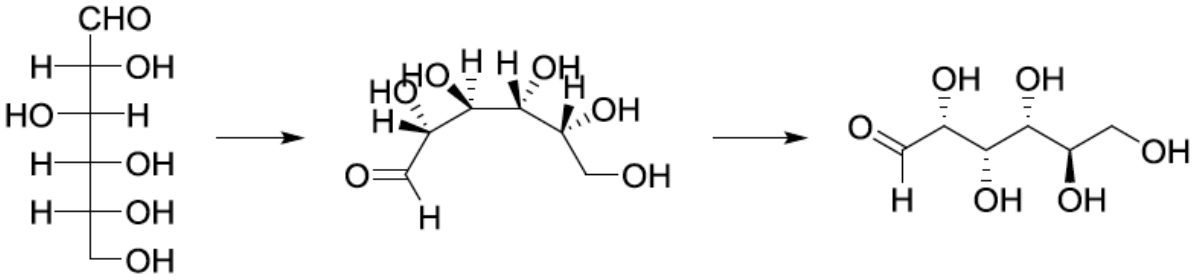
b) The graph would resemble that of ethane. All eclipsed conformations have the same interactions and would have the same strain energy.



Question 8 (4 points)

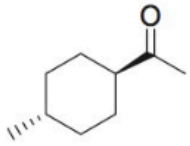
For the following Fisher projections, draw the corresponding zig-zag line drawing

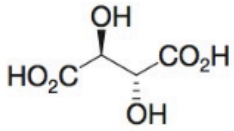


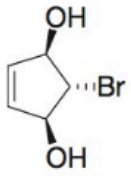


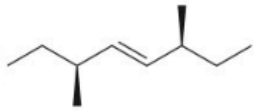
Question 9 (3 points)

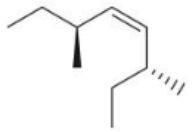
Determine which of the following compounds are chiral and which are achiral. For those that are achiral, indicate whether they are also a meso compound.

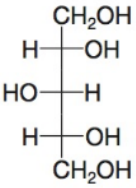
a) 

b) 

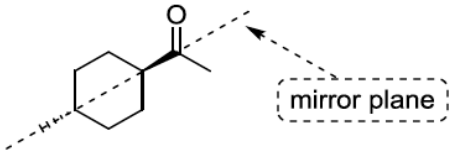
c) 

d) 

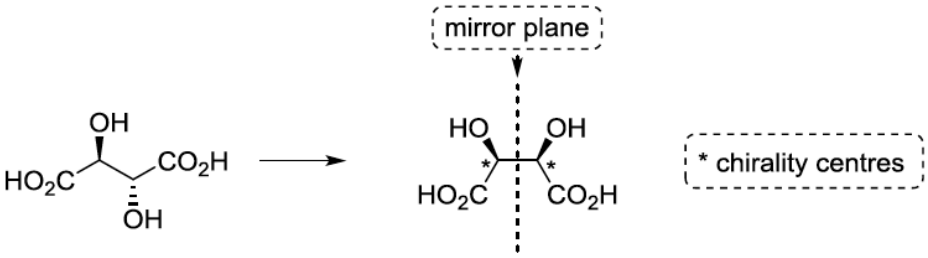
e) 

f) 

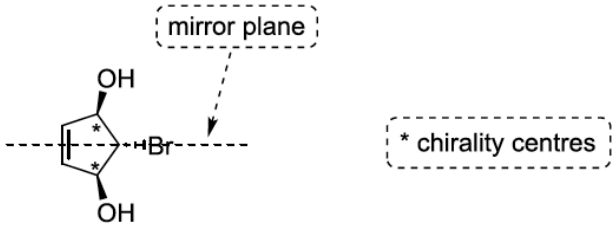
None of the carbons has four different substituents in this molecule. This molecule is achiral.



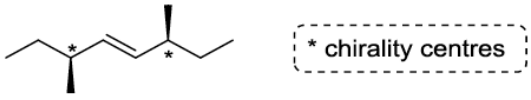
There are two chiral carbons in this molecule, but they are reflected through a mirror plane in the molecule. This is a meso compound and is achiral.



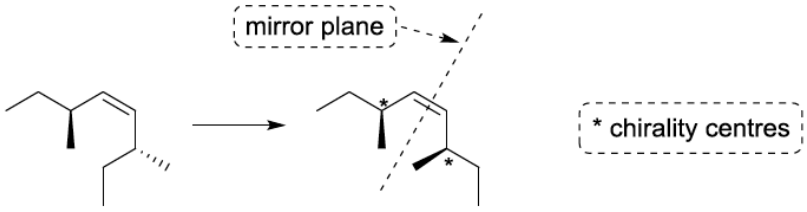
c) This molecule has an internal mirror plane of symmetry. This is a meso compound and is achiral.



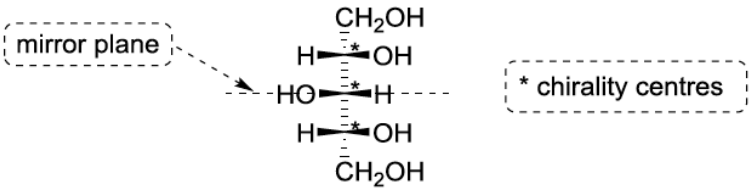
d) There are two chirality centres and no internal mirror plane. This is a chiral molecule.



e) There are two chirality centres in this molecule, but they are reflected through a mirror plane in the molecule. This is a meso compound and is achiral.

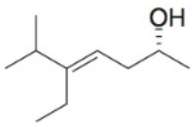


f) This molecule has an internal mirror plane of symmetry. This is a meso compound and is achiral.

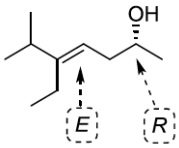


Question 10 (1 point)

Select the correct IUPAC name for the following compound:



a) (*R*,*Z*)-5-ethyl-6-methylhept-4-en-2-ol
b) (*S*,*Z*)-5-ethyl-6-methylhept-4-en-2-ol
c) (*R*,*E*)-5-ethyl-6-methylhept-4-en-2-ol
d) (*S*,*E*)-5-ethyl-6-methylhept-4-en-2-ol



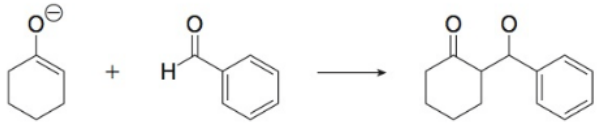
So, the answer would be (c): (*R*,*E*)-5-ethyl-6-methylhept-4-en-2-ol.

Question 11 (3 points)

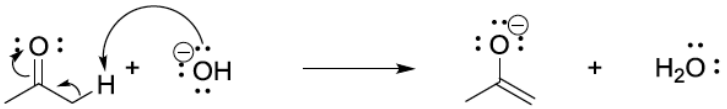
For each of the following reactions, add mechanistic arrows to show the flow of electrons. Where appropriate, include lone pairs, as well as any formal charges missing from the products.

a)

b)



a)



b)