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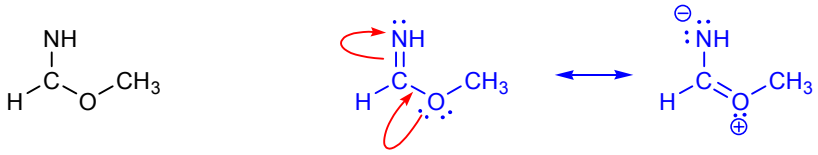
CHE321 **Exam 1** **9/26/2006**

Multiple Choice Questions. 60 points

1. Draw the two best contributing structures for methylimidate.
To get you started a partial structure is given.



Choose the *incorrect* statement.

(A) Both contributing structures have the same number of electrons.

(B) Both contributing structure have exactly the same geometry.

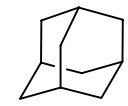
(C) One of the contributing structures has a negative charge on the nitrogen atom.

(D) One of the contributing structures has a positive charge on the oxygen atom.

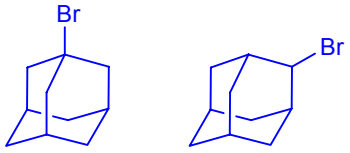
(E) A double bond exists between the carbon and nitrogen atoms in both structures.

analysis: This question requires you know how to draw different electron configurations (contributing structures or resonance structures) of a given molecule. This topic was discussed in the lecture and was part of quizzes and workshop problems. Scores for this question were high, 72% correct.

2. The carbon frame work of the molecule adamantane, $C_{10}H_{16}$, is shown below.



adamantane



Choose the correct number of bromoadamatanes ($C_{10}H_{15}Br$) that are possible.

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

analysis: This is a difficult problem if you had not done part 3 of workshop 2. Adamantane is a very symmetrical structure and there are only two different hydrogen atoms. Performance on this question was the poorest for all of the multiple choice questions, 26% correct.

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3. From a consideration of the molecular orbital treatment of the hydrogen molecule, choose from the following statement that is *incorrect*.

   (A) The molecular orbitals are formed from combinations of the 1s orbitals from each of the two hydrogen atoms.

   (B) The lower molecular orbital is a σ (sigma) bonding orbital.

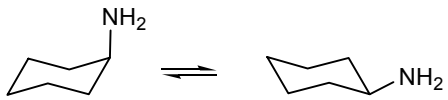
   (C) The higher molecular orbital is a σ (sigma*) antibonding orbital.

   (D) Each of the two molecular orbitals will be occupied electrons fifty percent of the time.

   (E) The electron density on each of the two hydrogen atoms is equal.

analysis: This question requires just a general understanding of molecular orbital theory and orbitals. Molecular orbital theory will be used throughout the course to help us understand certain chemical phenomena. 68% of the students got this question correct.

4. Estimate the equilibrium constant for the following transformation.



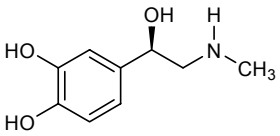
$\Delta G^\circ = -RT \ln K_{eq}$

$= -5.72 \text{ kJ mol}^{-1} \log K_{eq}$ (at room temperature)

(A) 0.01 (B) 0.1 (C) 1 (D) 10 (E) 100

analysis: There is an intimate relationship between changes in molecular structure (organic reactivity) with energy. A qualitative understanding of this logarithimic relationship will assist in understanding why small changes in structure can result in huge changes in reaction rates and equilibria. This subject was part of a in class quiz. 66% of the class got this question correct.

5. Epinephrine is a hormone and neurotransmitter produced by the adrenal medulla and has the following structure. Choose the statement that correctly identifies some of the functional groups present in epinephrine.



epinephrine

(A) alcohol, ester, aromatic (B) amine, alcohol, amide (C) amide, aromatic, alkane
(D) amine, alcohol, aromatic (E) alkane, ether, aromatic

analysis: Organic chemistry is organized according to functional groups so it is necessary to know the common functional groups for education to proceed. The class did very well on this question, 84%

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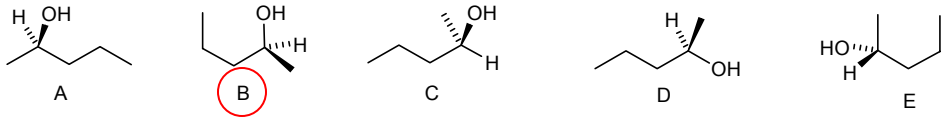
6. Which of the following structures would not have a dipole moment in its most stable conformation.

(A) 1,1-dichlorocyclohexane (B) *cis*-1,2-dichlorocyclohexane (C) *trans*-1,2-dichlorocyclohexane
(D) *cis*-1,4-dichlorocyclohexane (E) *trans*-1,4-dichlorocyclohexane

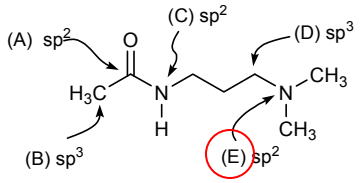
analysis: The answer to this question is best seen by using molecular models. Answer E has a center of symmetry so any bond dipole has an identical bond dipole oriented at 180°. A similar question was part of in an in class quiz. 66% of the class got this question correct.

7. Which of the following structures does not represent the same compound as the other four.



analysis: Chemistry occurs in three dimensions so it is important we be able to unambiguously communicate three dimensional information using a two dimensional piece of paper. The simplest way to approach this problem is to assign absolute stereochemistry to each of the stereocenters in order to see which of them is identical. A similar problem was an in class problem. 68% of the class got this correct.

8. Given that the amide functionality is planar, choose the atom that is identified with the incorrect hybridization.



analysis: VSEPR theory can be used to determine the correct geometry of each of the atoms. The atom hybridization that best accommodates these geometry is correct. Because of the presence of a lone pair on the amine nitrogen atom, it has a tetrahedral geometry using sp^3 hybrid orbitals in its bonds. Being able to predict the shapes of molecules as well as the nature of their bonding is fundamental to understanding their biological and chemical behavior. 64% of the class got this correct.

9. Choose the statement that is ***incorrect*** about rings.

(A) The chair conformation of cyclohexane has no angle or torsional strain.
(B) Cyclopropane has the greatest angle strain.
(C) Planar cyclobutane is its most stable conformation.
(D) Planar cyclopentane would have small angle strain but severe torsional strain.
(E) The chair conformation has less torsional strain and fewer nonbonded interactions than the twist boat conformation.

analysis: Angle strain, torsional strain and steric effects are all important in determining the shape of molecules such as rings.. The ideas in this question were discussed at the beginning of the in class discussion of cycloalkanes. 50% of the class got this correct.

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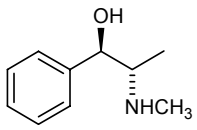
10. Ephedrine is chiral compound isolated from the plant *ephedra sinica* and has the following molecular structure.



Choose the ***incorrect*** statement about ephedrine.

(A) The mirror image structure of ephedrine is its enantiomer.

(B) The ephedrine shown above has two diastereomers.

(C) Ephedrine and all of its diastereomers must have the same melting point.

(D) Ephedrine and its enantiomer have the same melting point.

(E) Ephedrine and enantiomer are stereoisomers.

analysis: Ephedrine has two stereocenters giving four stereoisomers with enantiomeric (mirror image) and diastereomeric relationships (stereoisomers that are not enantiomers) among them. An understanding of biological and chemical properties requires an understanding of molecular structures that all have the same bonds but different orientation of their atoms in space (stereoisomers). 70% of the class got this correct.

11. Choose the ***incorrect*** statement about ephedrine and its enantiomer. (see above question for the structure of ephedrine)

(A) The molecular weights of both enantiomers are the same.

(B) The melting points of both enantiomers are the same.

(C) Both enantiomers rotate the plane of polarized light the same number of degrees but in opposite directions.

(D) The color of the two enantiomers must be the same.

(E) The toxicity of the two enantiomers must be equal.

analysis: Ephedrine has two stereocenters giving four stereoisomers with enantiomeric (mirror image) and diastereomeric relationships (stereoisomers that are not enantiomers) among them. An understanding of biological and chemical properties requires an understanding of molecular structures that all have the same bonds but different orientation of their atoms in space (stereoisomers). 64% of the class got this correct.

12. Choose the correct molecular formula for ephedrine.

(A) $C_{10}H_{15}NO$ (B) $C_{11}H_{15}NO$ (C) $C_{10}H_{16}NO$ (D) $C_{10}H_{14}NO$ (E) $C_9H_{15}NO$

analysis: Future progress in organic chemistry requires an understanding of the symbolism represented by a molecular structure. 74% of the class got this correct.

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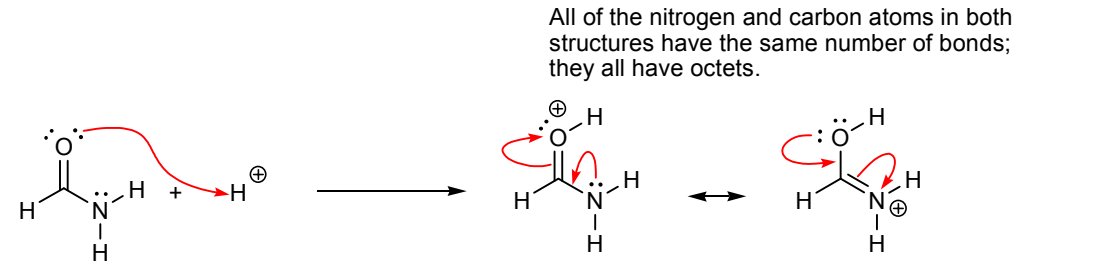
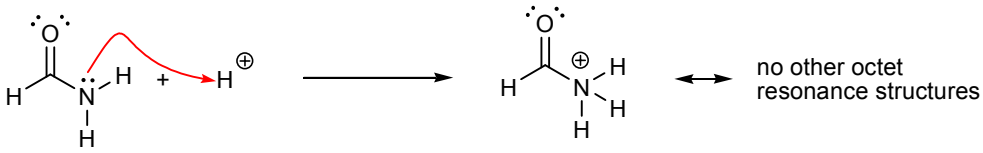
Short Answer Questions. 40 points.

13. Formamide undergoes protonation on oxygen when treated with strong acid. Draw the two best contributing structures for this cation, identify the major contributor and, using the curved arrow formalism, show the bond making and bond breaking that occurs to interconvert these two structures.

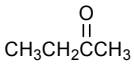




analysis: Protonation of the oxygen verses the nitrogen atom is predicted to occur since the product is stabilized by electron delocalization. Both of these resonance structures have the same number of bonds so the electronic structure with the positive charge on nitrogen would contribute more to the description of the protonated amide than the structure with the positive charge on the more electronegative oxygen atom. This question was part of workshop #4.

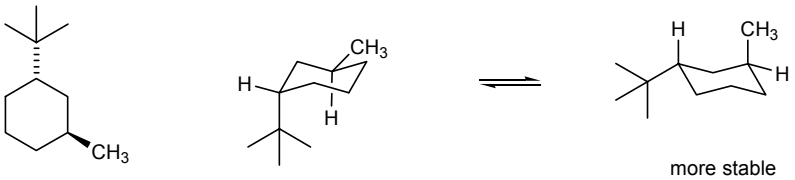
14a. Give the correct structure for compound with the name (3*R*, 5*S*)-3,5-dimethyloctane.
analysis: This type of question will be asked throughout CHE 321-2. Communication using the language of chemistry is essential.

14b. Give the correct name for the following structure.



analysis: This type of question will be asked throughout CHE 321-2. Communication using the language of chemistry is essential.

15. The following cyclohexane derivative is rapidly interconverting between two chair conformations. Draw these two chair conformations and identify the more stable structure.



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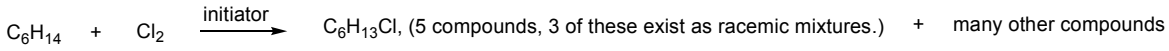
analysis: Six membered rings are ubiquitous in organic chemistry. Progress in the rest of this course requires an understanding of the shape of six membered rings and the factors that affect the stabilities of their various conformations.

16. The treatment of hydrocarbons with chlorine in the presence of an initiator involves the substitution of a C-H by a C-Cl. This reaction will be discussed further in Chapter 8.

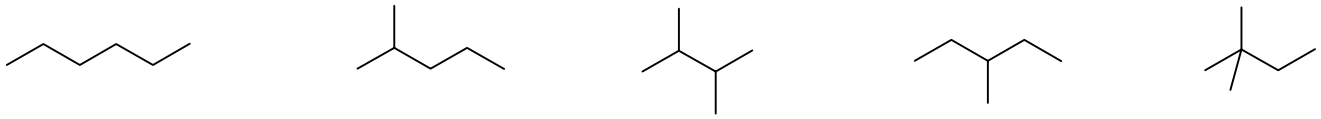
    The chlorination of a hydrocarbon **A** (C_6H_{14}) gives a complex mixture from which can be separated five different compounds with the formula $C_6H_{13}Cl$. On further study it is observed that three of these five compounds are actually racemic mixtures.

    Give the structure of hydrocarbon **A** and draw one chiral and one achiral $C_6H_{13}Cl$ derivative of hydrocarbon **A**.



analysis: This is a typical problem in organic chemistry that has analogs in many areas. In this problem you are given some information and you must arrive at an answer that is consistent with this information.

1. Compound A has the formula C_6H_{14}. There are five constitutional isomers represented by the formula C_6H_{14}. Compound A must be one of the following.



2. Substitution of one H with Cl results in five different compounds. Only 2-methylpentane is consistent with this data. The three structures containing stereocenters that would give racemic mixtures are indicated with *.