



NAME (Print): \_\_\_\_\_

Chemistry 320M/328M  
Dr. Brent Iverson  
1st Midterm  
September 27, 2018

SIGNATURE: \_\_\_\_\_

Please print the  
first three letters  
of your last name  
in the three boxes

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**Please Note:** This test may be a bit long, but there is a reason. I would like to give you a lot of little questions, so you can find ones you can answer and show me what you know, rather than just a few questions that may be testing the one thing you forgot. **I recommend you look the exam over and answer the questions you are sure of first**, then go back and try to figure out the rest. Also make sure to **look at the point totals** on the questions as a guide to help budget your time.

**You cannot use a red pen to take the exam. You must have your answers written in PERMANENT ink if you want a regrade!!!! This means no test written in pencil or ERASABLE INK will be regraded.**

Please note: We routinely photocopy a number of exams following initial grading to guard against receiving altered answers during the regrading process.

**FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENTS YOU ARE NOT ALLOWED TO INTERACT WITH YOUR CELL PHONE IN ANY WAY. IF YOU TOUCH YOUR CELL PHONE DURING THE EXAM YOU WILL GET A "0" NO MATTER WHAT YOU ARE DOING WITH THE PHONE. PUT IT AWAY AND LEAVE IT THERE!!!**

Page	Points
<b>1</b>	<b>(20)</b>
<b>2</b>	<b>(22)</b>
<b>3</b>	<b>(15)</b>
<b>4</b>	<b>(20)</b>
<b>5</b>	<b>(29)</b>
<b>6</b>	<b>(36)</b>
<b>7</b>	<b>(17)</b>
<b>8</b>	<b>(20)</b>
<b>9</b>	<b>(16)</b>
<b>10</b>	<b>(14)</b>
<b>11</b>	<b>(20)</b>
<b>12</b>	<b>(24)</b>
<b>13</b>	<b>(16)</b>
<b>14</b>	<b>(35)</b>
<b>15</b>	<b>(4)</b>
<b>16</b>	<b>(12)</b>
<b>Total</b>	<b>(320)</b>





Signature \_\_\_\_\_

Pg 1 \_\_\_\_\_(20)

1. (4 points) What is the most important question in Organic Chemistry?

2. (8 pts each) For the following molecular formula, draw complete Lewis line structures in which all atoms (even H atoms) are drawn, lines are used as bonds, all lone pairs are drawn AND ALL FORMAL CHARGES ARE INDICATED. Note you must infer the formal charges as we do not indicate them on the chemical formulas given



How many different stereoisomers are possible for the above molecule? \_\_\_\_\_

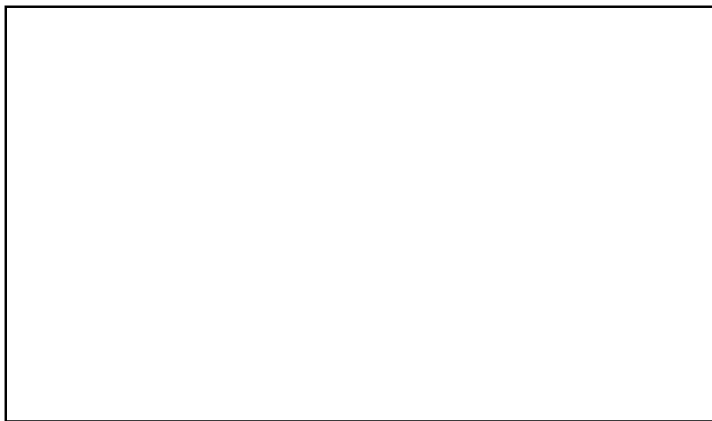


How many different stereoisomers are possible for the above molecule? \_\_\_\_\_

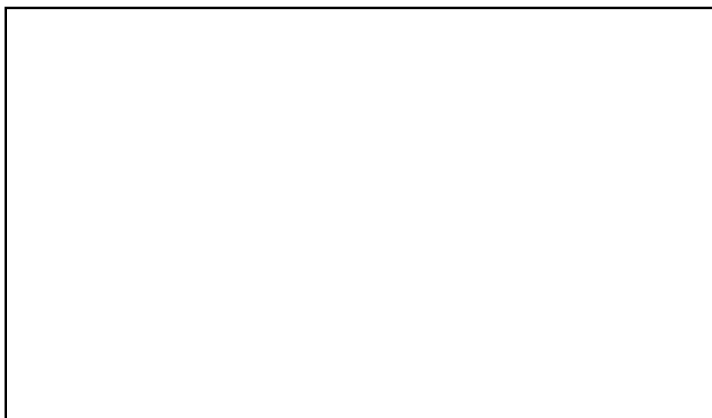


4. (5pts each) For the following IUPAC names, draw the appropriate line angle drawing (you can ignore R and S for the first two, but not the bottom one).

A) **9-ethyl-6-isopropyl-2,3,4-trimethylundecane**



B) ***trans*-1,4-diisopropylcyclohexane**

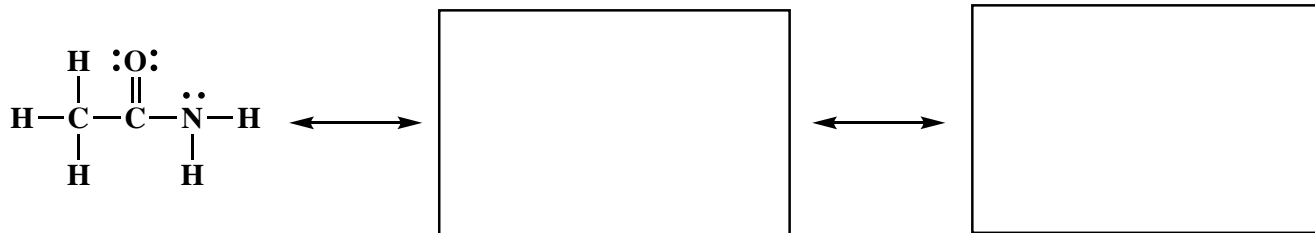


C) **(*R*)-2,4,7-trimethyloctane (Use wedges and dashes to indicate the appropriate stereochemistry at all chiral centers)**



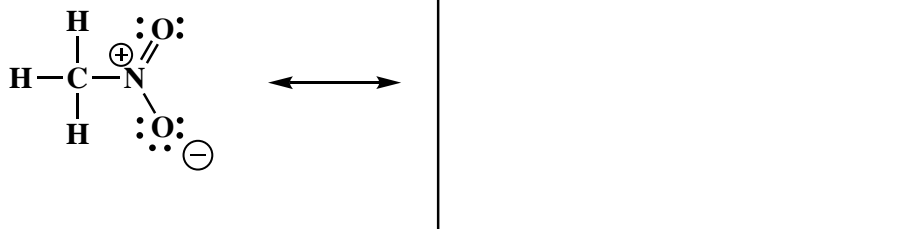


5. (10 pts) I told you this would be here. The following amide molecule is best represented as the hybrid of three contributing structures. **Draw the second and third important contributing structures** in the spaces provided, including all lone pairs and formal charges. **For the two structures on the left use arrows to indicate the movement of electrons to give the structures you drew.** There is **no need to draw any circles around any of these contributing structures**. You might want to read these directions again to make sure you know what we want.

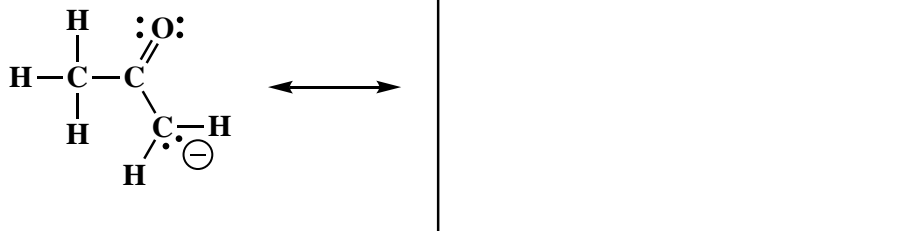


6. (5pts each) The following molecules are best represented as the hybrid of contributing structures. **Draw the second important contributing structure** in the space provided, including all lone pairs and formal charges. **For the structure on the left, use arrows to indicate the movement of electrons to give the structure you drew.** Finally, if one of the two contributing structures makes a dominant (major) contribution to the resonance hybrid, **draw a circle around the dominant (major) contributor**. You might want to read these directions again to make sure you know what we want.

A.

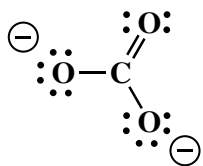


B.

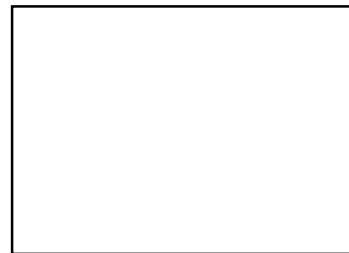
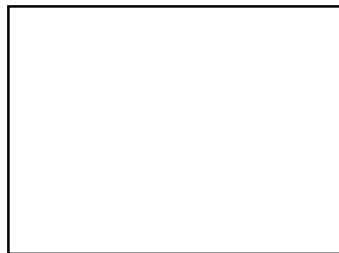
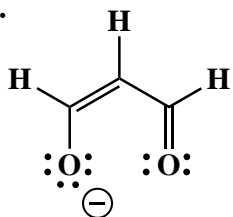


7. (10 pts each) The following molecules are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. For the two structures on the left in each problem, use arrows to indicate the movement of electrons to give the structures you drew. There is no need to draw any circles around any of these contributing structures. You might want to read these directions again to make sure you know what we want.

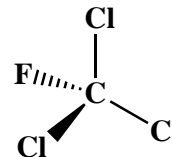
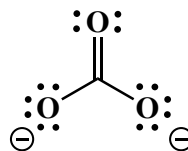
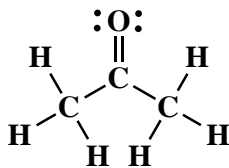
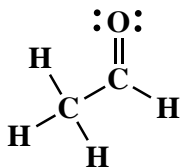
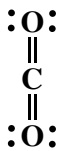
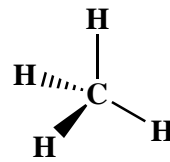
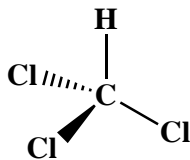
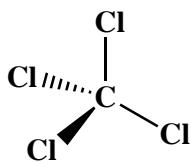
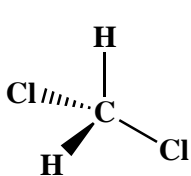
A.



B.



8. (1 pt each) Circle any molecule that has an overall molecular dipole moment.



Signature \_\_\_\_\_

Pg 6 \_\_\_\_\_(36)

9. (2 pts each) Fill in each blank with the word or words that best completes the sentences.

For organic chemistry, it is best to think of electrons as \_\_\_\_\_.

The electron density in molecules can be described mathematically by adding the wave functions of all the atomic orbitals for all the atoms in the entire molecule, an approach referred to as \_\_\_\_\_ theory.

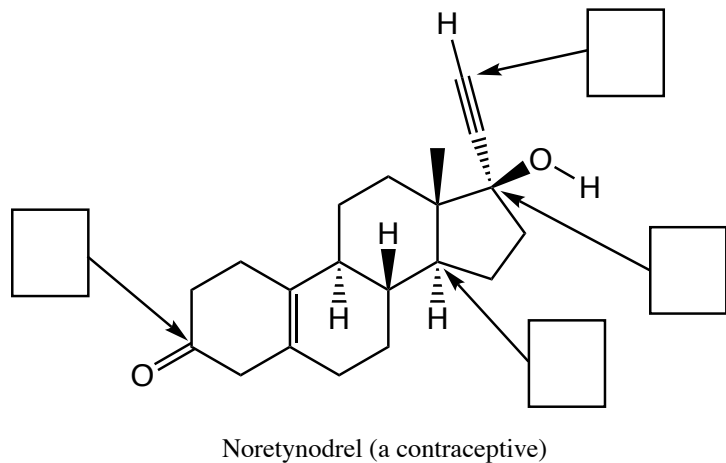
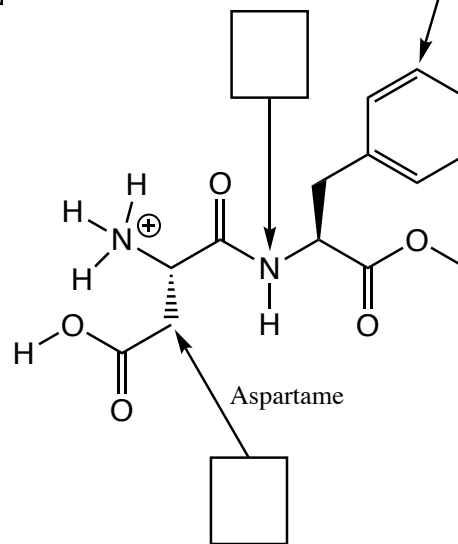
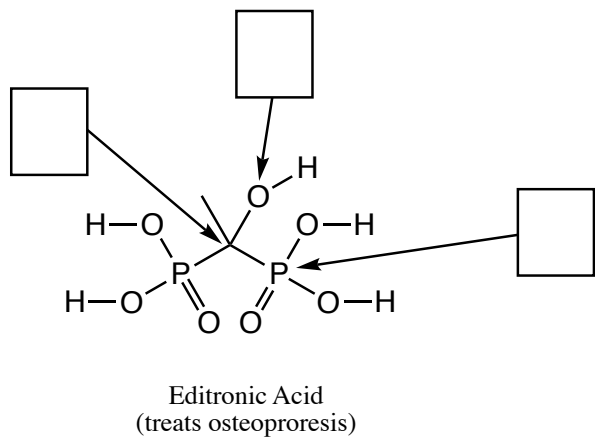
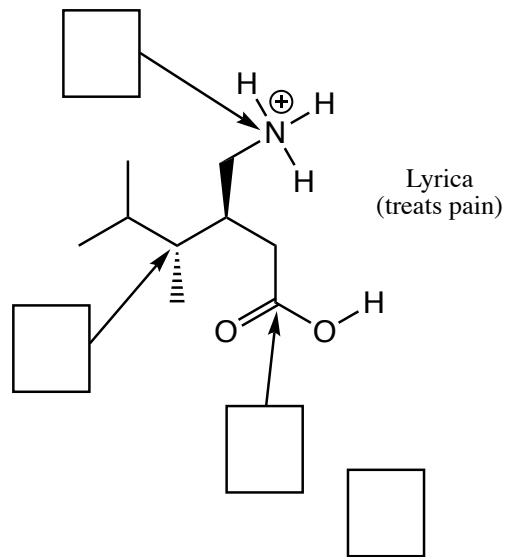
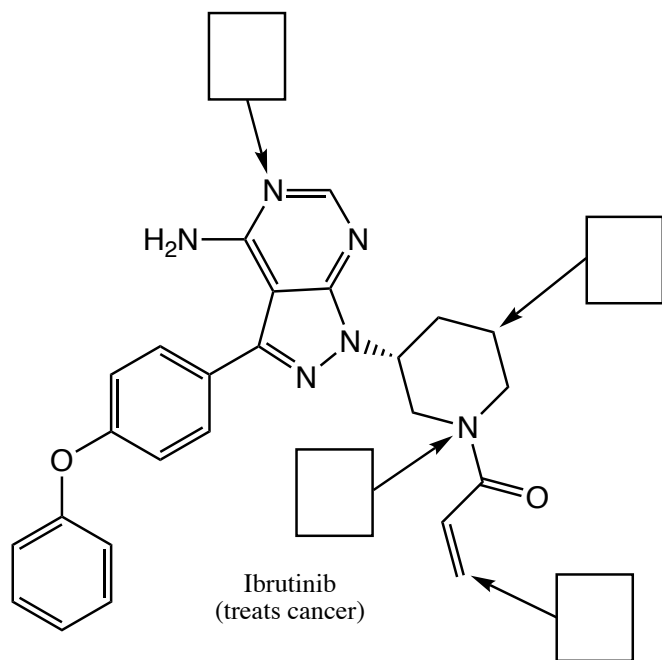
The wave functions for the valence atomic orbitals on each atom can be added together first, a process referred to as \_\_\_\_\_, before looking for overlap with orbitals from other atoms. This approach is called \_\_\_\_\_ theory.

You need to be able to think about all \_\_\_\_\_ bonding in molecules as being derived from the overlap of \_\_\_\_\_ orbitals and all pi bonding as being derived from overlap of unhybridized \_\_\_\_\_ orbitals.

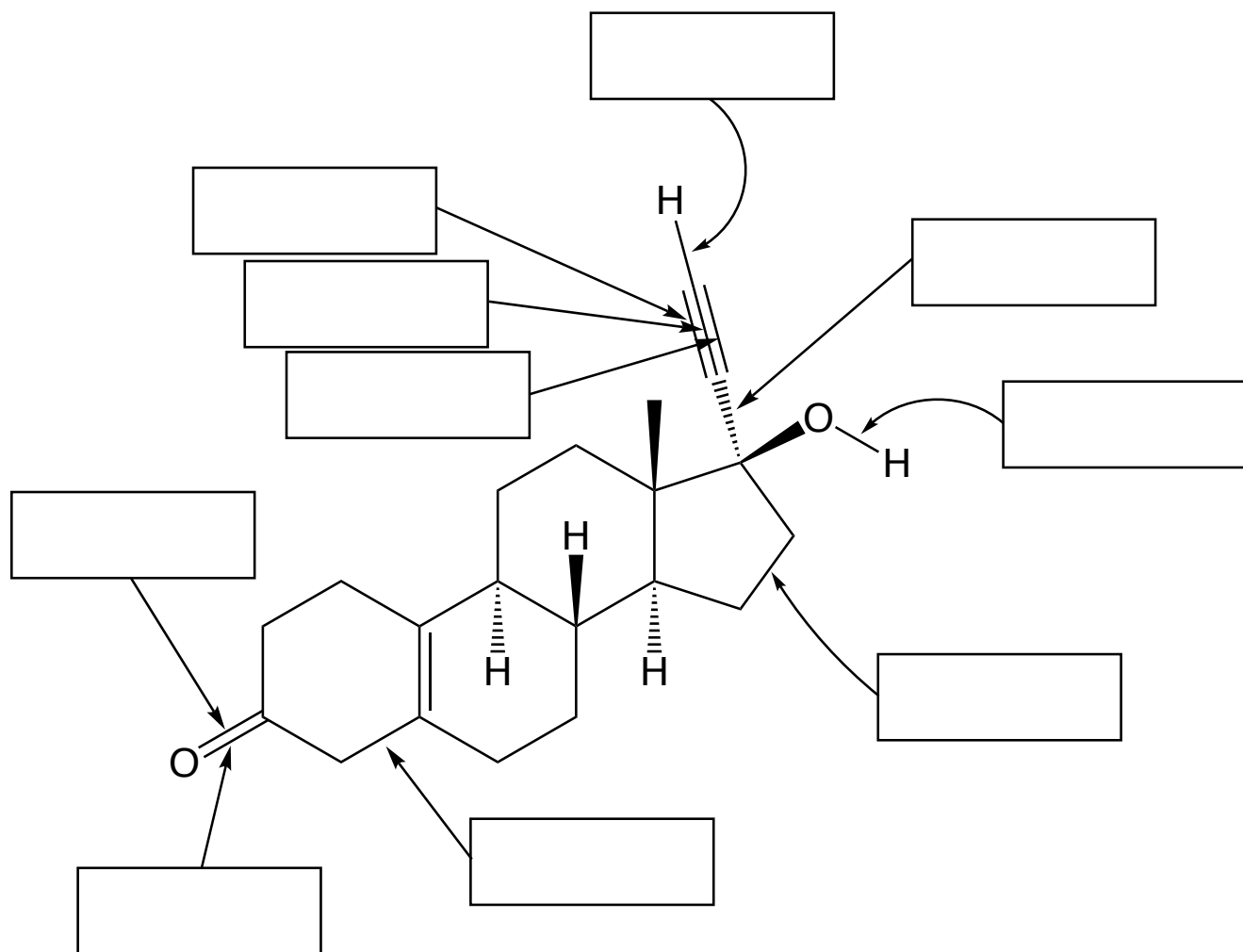
Three (or more) atom "pi-waves" are the situation resonance \_\_\_\_\_ structures are usually trying to describe. Individual \_\_\_\_\_ structures can only describe pi bonding between \_\_\_\_\_ atoms, not \_\_\_\_\_ or more, explaining why the \_\_\_\_\_ structures are needed for these situations.

For pi bonding and therefore pi delocalization to occur over more than \_\_\_\_\_ atoms (i.e. pi-waves), parallel \_\_\_\_\_ orbitals are needed on ALL of the adjacent atoms involved, explaining why ALL of these atoms must be \_\_\_\_\_ (or \_\_\_\_\_) hybridized and why these systems are planar.

10. (1 pt each) In the boxes provided, write the hybridization state of the atoms indicated by the arrow.

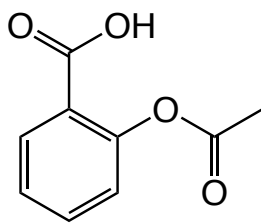


11. (2 pts each) Describe each bond indicated with an arrow as the overlap of orbitals. For example, an answer might be  $\sigma_{\text{Csp}^3-\text{Csp}^3}$ .

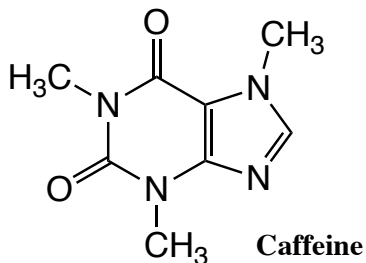


Noretynodrel (a contraceptive)

12. (16 pts) Circle all of the molecules that are chiral. Put an asterisk (\*) next to all chiral centers.



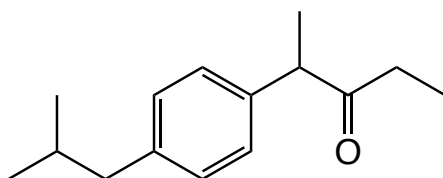
Aspirin



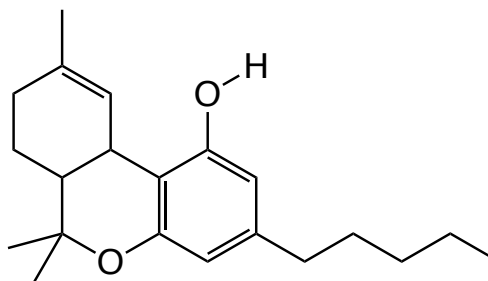
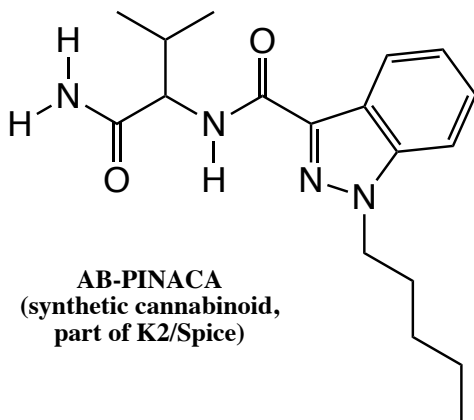
Caffeine



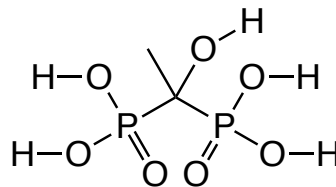
Notice this!!



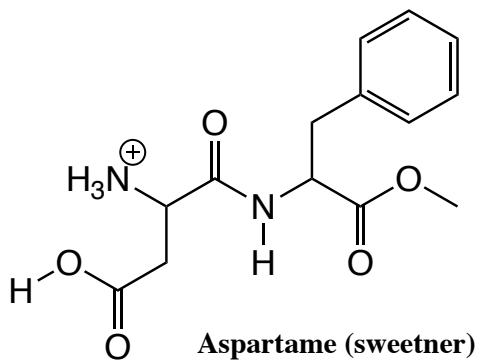
Ibuprofen (Advil)

 $\Delta^9$ -THC (from Marijuana)

AB-PINACA  
(synthetic cannabinoid,  
part of K2/Spice)



Editronic Acid  
(treats osteoporosis)



Aspartame (sweetner)

How many stereoisomers of Aspirin are possible?

\_\_\_\_\_

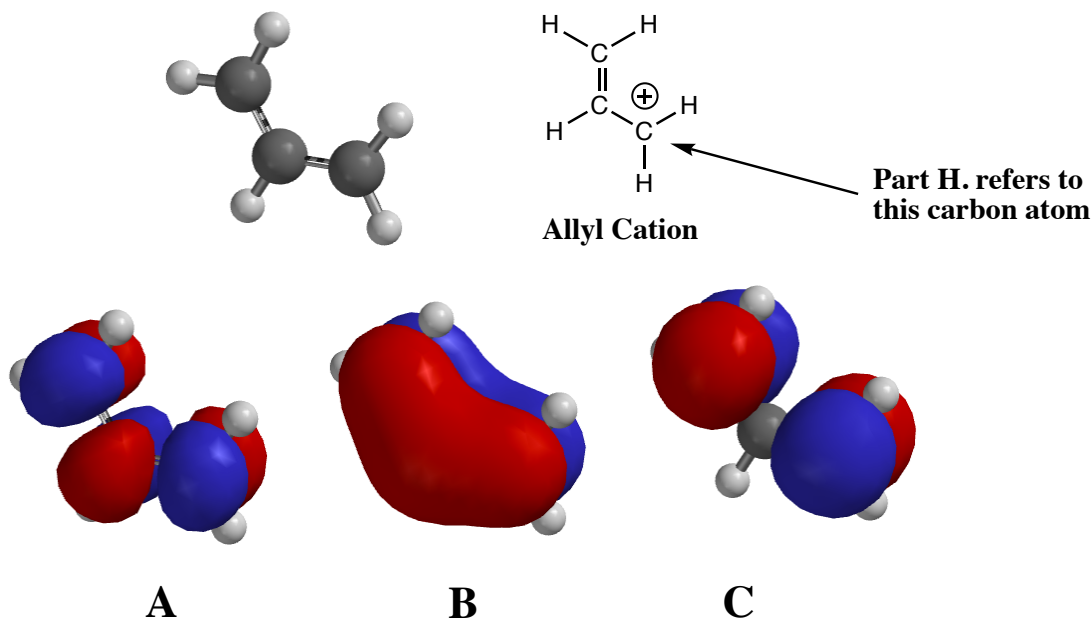
How many stereoisomers of Ibuprofen are possible?

\_\_\_\_\_

How many stereoisomers of Aspartame are possible?

\_\_\_\_\_

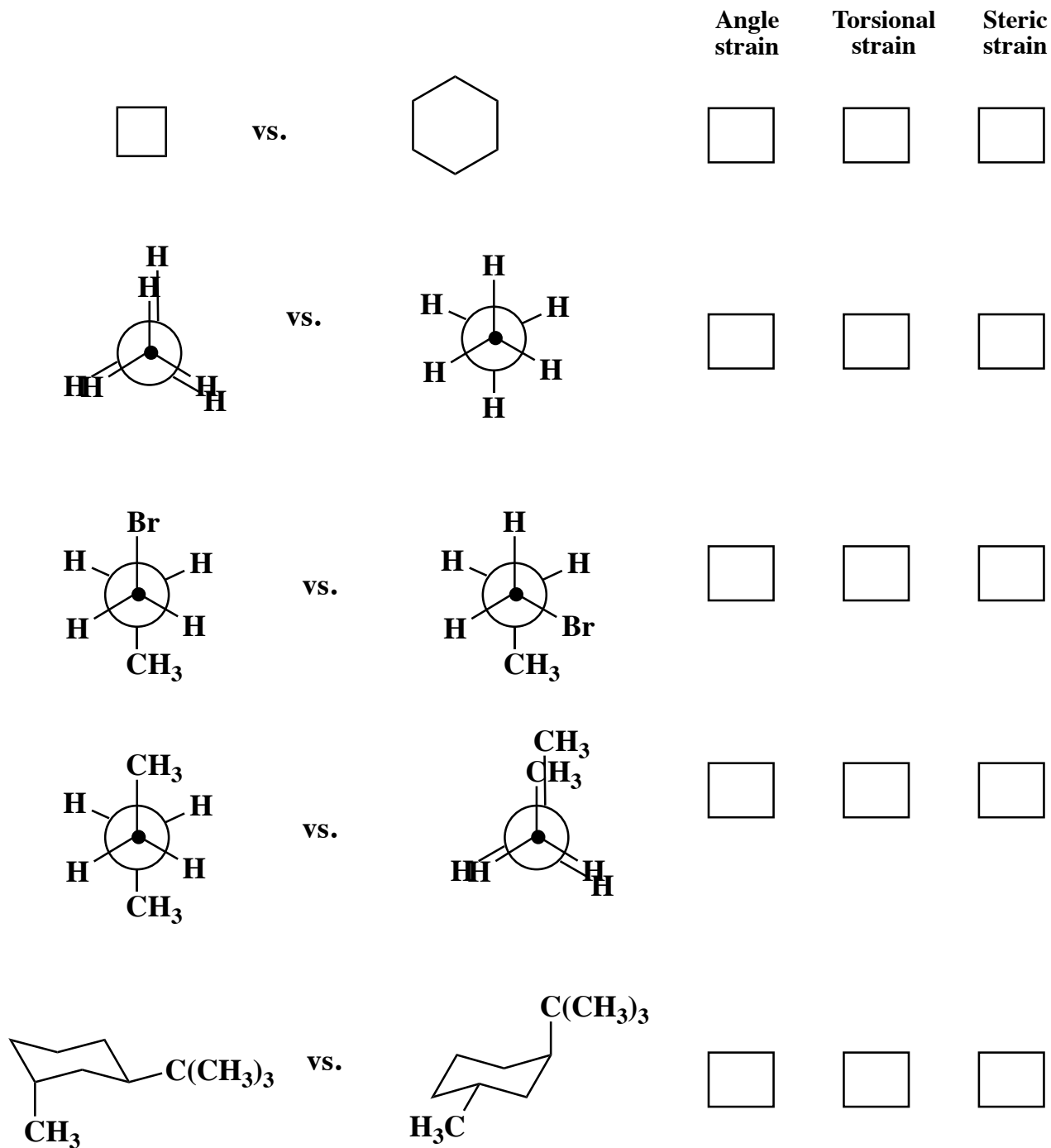
13. (2 pts each right answer) We expect this to be a challenge, it will test your understanding of pi orbitals. Carbocations are carbon atoms that have a “+” formal charge. They are generally very reactive. Look at the three calculated pi orbitals for the so-called allyl cation, a particularly stable carbocation.



We do not expect that you can calculate these orbitals on your own, but you should have some idea about what they mean. Orbitals define an area of space in which electron density is located as well as an energy.

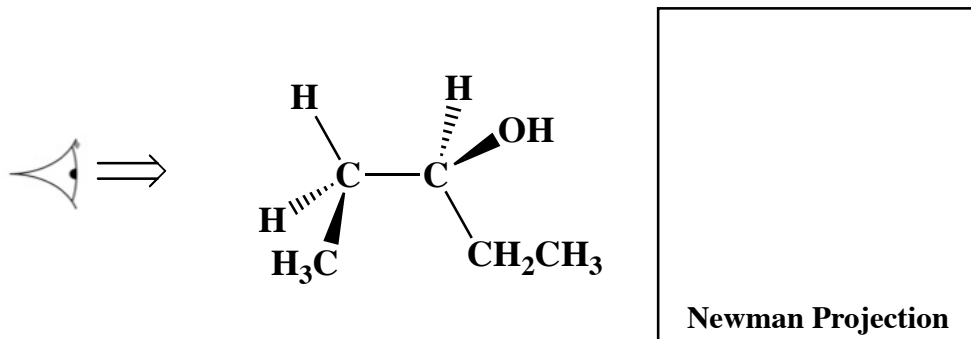
- A. Which of the three orbitals; A, B, or C is the HIGHEST in energy? \_\_\_\_\_
- B. Which of the three orbitals; A, B, or C is the LOWEST in energy? \_\_\_\_\_
- C. In this allyl cation, how many electrons are located in these pi orbitals? \_\_\_\_\_
- D. Write the letter(s) of the orbital(s) that is/are filled with electron pairs \_\_\_\_\_
- F. Write the letter of the orbital that best explains why the allyl cation is more stable than most carbocations \_\_\_\_\_
- G. Think about the other important contributing structure for the allyl cation beyond the one shown above. Given your second contributing structure, the positive charge is located on how many of the carbon atoms of the allyl cation? \_\_\_\_\_
- H. What must the hybridization state be of the atom shown with the formal “+” charge? \_\_\_\_\_

14. (4 pts each) For each pair of molecules, circle the one that has LESS STRAIN, then put an "X" in the box under all the types of strain that explain(s) your answer:





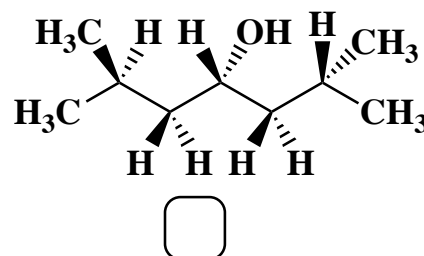
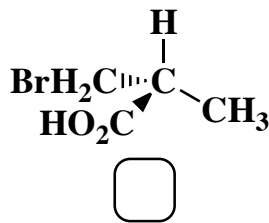
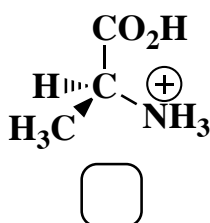
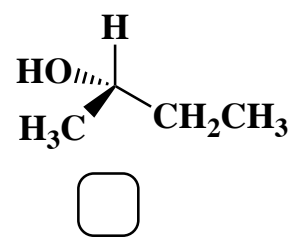
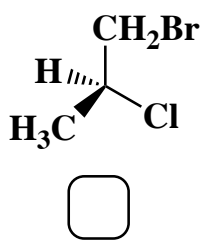
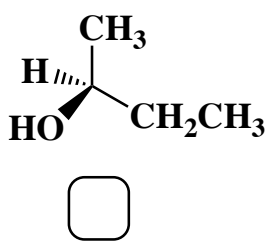
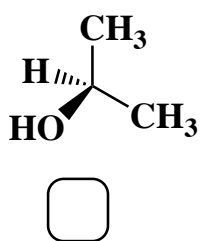
15. (5 pts) Draw the Newman projection for the conformation of 3-pentanol as shown.



16. (5 pts) In the empty box draw the conformation of 3-pentanol indicated by the Newman projection shown.



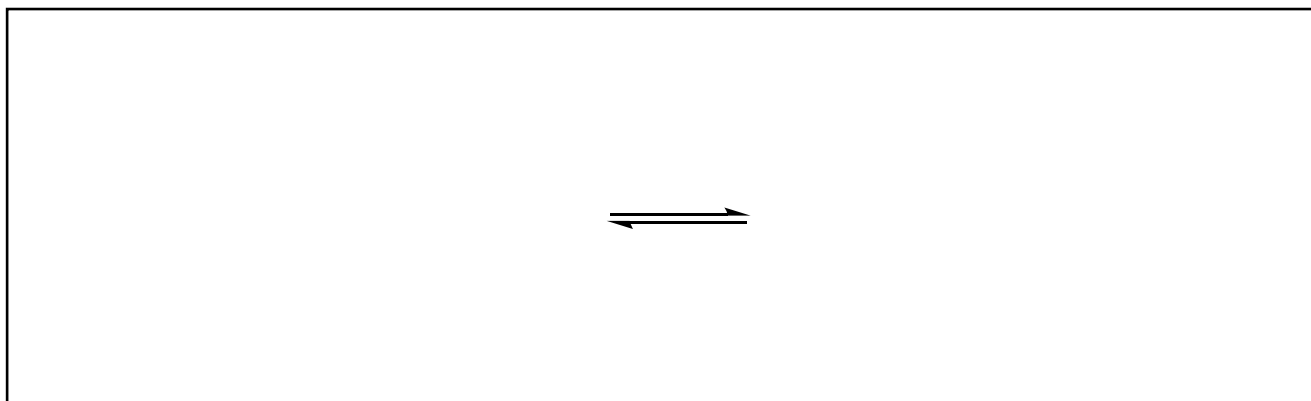
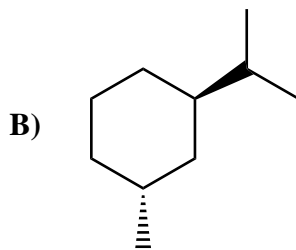
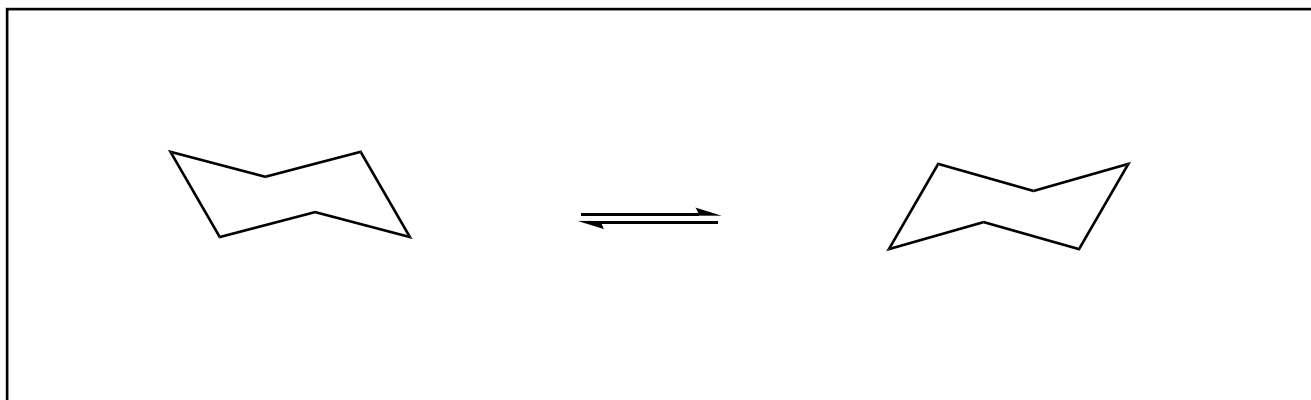
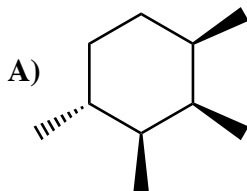
17. (2 pts each) Examine the following structures. For each molecule with a chiral center, assign the stereochemistry then write "R" or "S" as appropriate in the box provided below each structure. For all molecules that have no chiral centers, put an X in the box.



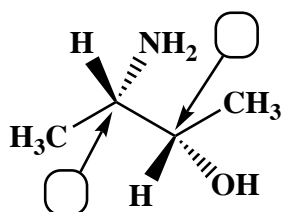
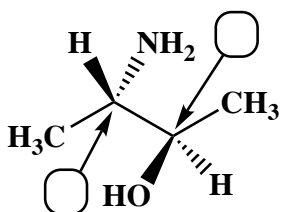
Signature \_\_\_\_\_

Pg 13 \_\_\_\_\_(16)

18. (16 pts) For the following cyclohexane derivatives, draw the two alternative chair conformations. IF there is a difference in stability, draw a circle around the more stable conformation. If there is not any difference in stability, do not circle either chair form.

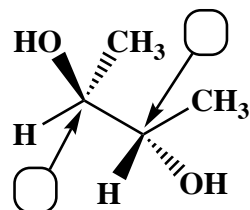
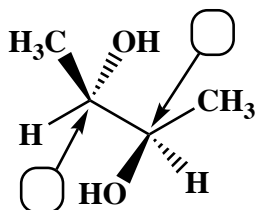


19. (35 pts) For each pair of molecules, on the line provided state the relationship between the two structures. Possible answers could be **enantiomers**, **diastereomers**, **constitutional isomers**, or **same molecule**. Draw a circle around any meso compound. In the boxes provided next to each chiral center, write "R" or "S" to indicate the absolute stereochemistry present.

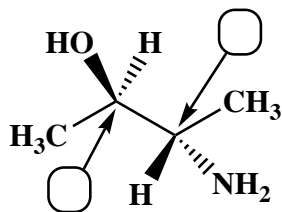
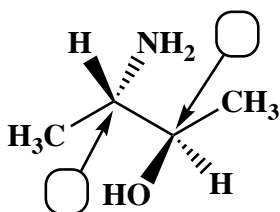


Relationship:

\_\_\_\_\_

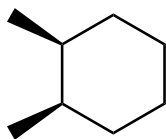
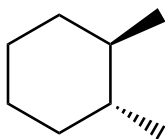


\_\_\_\_\_

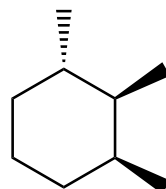
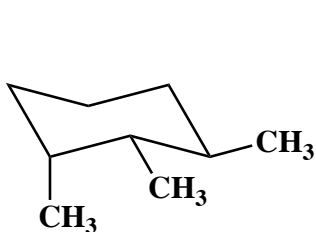


\_\_\_\_\_

You do not need to label the chiral centers with "R" or "S" on these last two



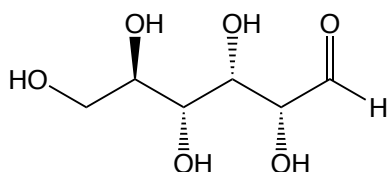
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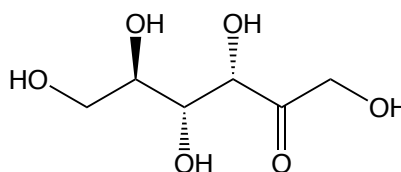
\_\_\_\_\_

20. (16 points total). Here is an “apply what you know” problem in the form of an MCAT style passage.

Carbohydrates such as glucose can be drawn in different forms. Next semester you will learn that carbohydrates equilibrate between a linear form and a ring form. In class last week I drew glucose in its six-membered ring form. For this problem, I will be drawing carbohydrates in their linear forms. Food is sweetened with natural carbohydrates or artificial sweeteners. Sugar cane, a primary source of the natural carbohydrate sucrose, only grows in certain climates, so it is relatively expensive. Therefore, much work has been done to find a low-cost, carbohydrate-based sweetener. Inspiration came from natural honey, which is sweet because it is mostly composed of a combination of two carbohydrates, glucose and fructose, in a roughly 4 to 3 ratio. Unfortunately, natural honey from bees is also relatively expensive and is only available in limited quantities. Glucose alone does not taste that sweet, but is available in vast quantities through inexpensive sources such as corn. A new approach to sweeteners, high fructose corn syrup, appeared in the 1970’s and has been growing in popularity ever since. High fructose corn syrup is a mixture of glucose and fructose in ratios similar to that found in natural honey. The key is that the fructose is made *from* glucose using a natural enzyme called glucose isomerase. The process is simple to describe; corn starch (inexpensive source of glucose from corn) is treated with the correct amount of the glucose isomerase enzyme to give the desired amount of fructose. The resulting mixture, called high fructose corn syrup, contains a precise glucose to fructose ratio reminiscent of honey, and is now used in essentially every type of food product because it is so inexpensive. I personally believe that high fructose corn syrup may be too inexpensive, as the incredibly low cost of products such as soda have undoubtedly contributed to the current obesity problem in this and other countries!



**Glucose**, drawn in its linear form



**Fructose**, drawn in its linear form

For the questions below, circle the best answer

1. (4 pts) What is the term that best describes the relationship between glucose and fructose?

- A. Constitutional isomers.
- B. Stereoisomers.
- C. Enantiomers.
- D. Diastereomers.

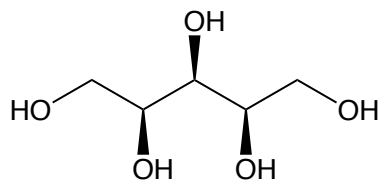
20. (cont.). Circle the best response

2. (4 pts) In the linear forms shown on the previous page, how many chiral centers are there in the two molecules:

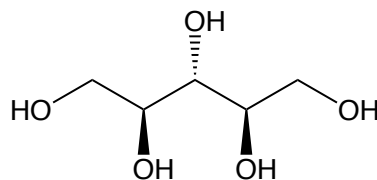
- A. There are 4 chiral centers in glucose and 4 chiral centers in fructose.
- B. There are 3 chiral centers in glucose and 3 chiral centers in fructose.
- C. Both of the molecules are meso compounds
- D. There are 4 chiral centers in glucose and 3 chiral centers in fructose.

3. (4 pts) How many different stereoisomers are possible for molecules that are the same constitutional isomer as glucose and the same constitutional isomer as fructose?

- A. There would be 16 different possible stereoisomers for molecules that are the same constitutional isomer as glucose, and 8 different possible stereoisomers for molecules that are the same constitutional isomer as fructose.
- B. There would be only one stereoisomer for each one because they are both meso compounds.
- C. There would be 16 different possible stereoisomers for molecules that are the same constitutional isomer as glucose, and 16 different possible stereoisomers for molecules that are the same constitutional isomer as fructose.
- D. There would be 8 different possible stereoisomers for molecules that are the same constitutional isomer as glucose, and 8 different possible stereoisomers for molecules that are the same constitutional isomer as fructose.



**Xylitol**



**Analog of Xylitol**

4. (4 pts) Another common sweetener added to food is the structurally related molecule xylitol (above left). Check out the stereochemistry of xylitol as well as the analog of xylitol drawn on the right.

Circle the statement that is true:

- A. Xylitol and the analog of xylitol shown above are enantiomers and are both meso compounds.
- B. Xylitol and the analog of xylitol shown above are constitutional isomers and are both meso compounds.
- C. Xylitol and the analog of xylitol shown above are diastereomers and are both meso compounds.
- D. Xylitol and the analog of xylitol shown above are enantiomers and neither is a meso compound.

**A good way to get ready for a 5K race is to remember that avoiding a running injury means being patient and increasing your distance slowly. Start by running as far as you can comfortably. Do not push it at the beginning. Let's say you can run 1 mile before feeling too out of breath. Run that 1 mile 2-3 times a week at first, making sure you have no foot or leg pain. If you do have foot/leg issues, try new running shoes fit by a professional (The Loop is a great running store for this). After you are comfortable running 1 mile for a week, try 1.25 miles for 2-3 times the next week. Then run to 1.5 miles, then 2.0 miles, then 2.5 miles each 2-3 times for a week. It will then be time for the race and you will make it!!!**