

**Useful Information: Strain energies**

$\text{CH}_3 \leftrightarrow \text{H}$	1, 3 diaxial interaction	3.8 kJ/mol
$\text{H} \leftrightarrow \text{H}$	eclipsed	4.0 kJ/mol
$\text{H} \leftrightarrow \text{CH}_3$	eclipsed	6.0 kJ/mol
$\text{CH}_3 \leftrightarrow \text{CH}_3$	eclipsed	11 kJ/mol
$\text{CH}_3 \leftrightarrow \text{CH}_3$	gauche	3.8 kJ/mol

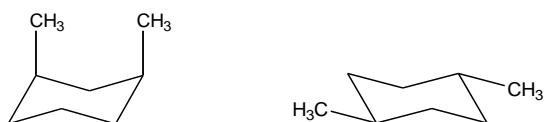
**Part 1. Multiple Choice (4 points each). Choose the one best answer, and clearly mark it on the test below.**

1. Which term best describes the relationship between the two structures shown below?



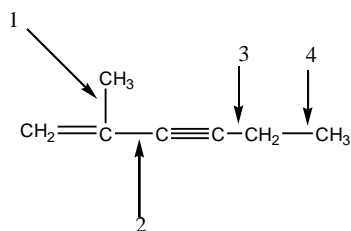
- a) conformers
- b) constitutional isomers
- c) stereoisomers
- d) identical
- e) different compounds with different molecular formulas

2. Which term best describes the relationship between the two structures shown below?



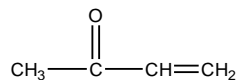
- a) conformers
- b) constitutional isomers
- c) stereoisomers
- d) identical
- e) different compounds with different molecular formulas

3. Of the C-C single bonds shown below, which is the strongest?



- a) 1
- b) 2
- c) 3
- d) 4
- e) All are equal in strength.

4. How many  $sp^2$  hybridized atoms are in the compound below?



- a) 1
- b) 2
- c) 3
- d) 4
- e) 5

5. Which compound is expected to have the highest boiling point?

- a) 2,2-dimethylpentane
- b) 2,4-dimethylpentane
- c) 2,2,3-trimethylbutane
- d) 3-methylhexane
- e) heptane

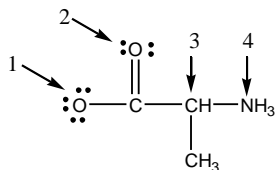
6. Which alkyl group, if any, is named incorrectly?

- a)  $(\text{CH}_3)_3\text{C}-$  *tert*-butyl
- b)  $(\text{CH}_3)_2\text{CH}-$  isopropyl
- c)  $(\text{CH}_3)_2\text{CHCH}_2-$  isobutyl
- d)  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)-$  *sec*-butyl
- e) All are correct.

7. Torsional strain results when

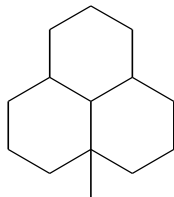
- a) groups of atoms approach each other too closely.
- b) bond angles deviate from the ideal  $109.5^\circ$  angle.
- c) orbitals have poor overlap.
- d) bonds on neighboring atoms are staggered.
- e) bonds on neighboring atoms are eclipsed.

8. What are the formal charges on the indicated atoms?



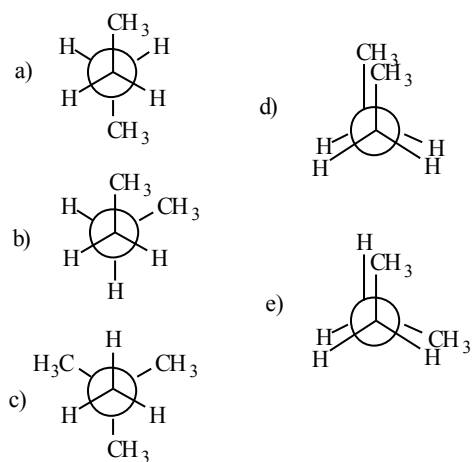
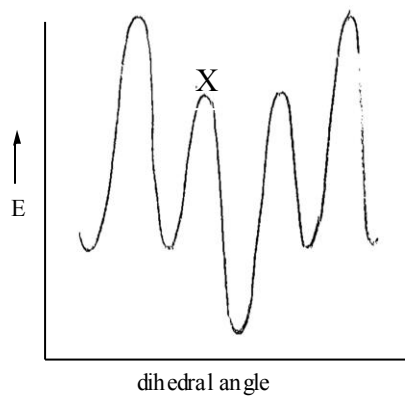
- |    | 1  | 2  | 3  | 4  |
|----|----|----|----|----|
| a) | -1 | 0  | 0  | +1 |
| b) | -1 | 0  | +1 | 0  |
| c) | 0  | -1 | +1 | 0  |
| d) | +1 | -1 | -1 | +1 |
| e) | -1 | 0  | +1 | -1 |

9. How many tertiary carbons are in the molecule shown?



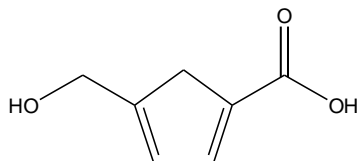
- a) 1
- b) 2
- c) 3
- d) 4
- e) 5
- f) more than 5

10. A plot of potential energy versus rotation about the C2-C3 bond in butane is shown below. Which Newman projection corresponds to point X on the diagram?

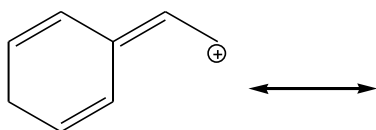


### Part 2. Short Answer

1. (6 points) What is the molecular formula of the compound shown?

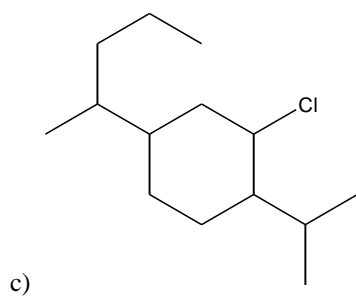
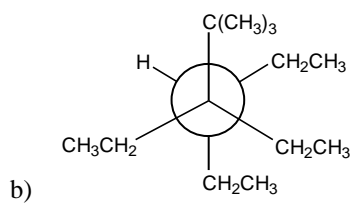


2. (6 points) Draw all resonance structures of the ion shown below.



3. (6 points) Draw the condensed structural formulas of all aldehydes having the formula  $C_5H_{10}O$ .

4. (6 points each) Give the complete IUPAC names of each compound below.



5. (8 points) Consider the following compound: 2,2,3-trimethylbutane. Sighting along the C2-C3 axis, draw the Newman projection of the *most* stable conformation, and draw the Newman projection of the *least* stable conformation. Calculate the total strain energy of each structure, and calculate the energy difference between the two structures.
6. (8 points) Consider the following two compounds:  
*trans*-1,3-dimethylcyclohexane  
*cis*-1,3-dimethylcyclohexane  
Draw the most stable conformation of each molecule. Indicate which molecule is more stable, and calculate the strain energy present in each molecule.
7. (8 points) Consider the conformation of methylcyclohexane with the methyl group in an axial position. Draw a Newman projection of this structure, sighting along both the C1-C2 axis and the C5-C4 axis.