NAME (print): ______________________________________________________________

TA:_____________ Sect. Day:______________ Sect. Time:______________

Take a few moments to look over the exam. Answer each question on the exam paper.

No calculators or electronic devices. You may use molecular models. Important clues and structures are in **bold**. There is a Periodic Table on page 7.

Do all *preliminary* drawing or computations on the work sheets at the end of the exam. The work sheets will not be graded. You may detach the work sheets from the exam.

The exam is 55 minutes.

STOP writing and hand in your exam when you are asked to do so.

**REMEMBER**: Neatness is to your advantage.

1. (20 pts) Conformation I
   ______

2. (20 pts) Conformation II
   ______

3. (25 pts.) Potpourri
   ______

4. (20 pts) Thermochemistry
   ______

5. (15 pts) Bonding/Orbitals
   ______

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Total (100 pts)
1. **Conformation I:** (20 pts) For the eclipsed and staggered conformations of 2,2-dimethybutane viewed along the C2-C3 sigma bond, **draw a Newman projection** of the most stable eclipsed and staggered conformations. Place the energies for each interaction in the Newman projections below. [Use the circles as templates for the Newman projections.] Calculate the total energy (kcal/mol) of both conformations. Place your answer in the appropriate box. [H/H, eclipsed, 1.0 kcal/mol; CH3/H eclipsed, 1.3 kcal/mol; CH3/CH3, eclipsed, 3.0 kcal/mol; CH3/CH3, gauche, 0.9 kcal/mol.] **Show your work!**

![Newman projections](image)
2. **Conformation II:** (20 pts) Consider the stereoisomer of 1-chloro-1,4-dimethylcyclohexane (1) shown here.

\[ \text{C}_9\text{H}_{13} \]

\[ \text{Cl} \quad \text{Cl} \]

\[ \text{CH}_3 \quad \text{CH}_3 \]

a) (10 pts) **Draw** the chair conformations below so that the equilibrium arrows are correct. Be sure all groups are **clearly** labeled axial or equatorial.

\[ \text{chair A} \quad \text{chair B} \]

b) (10 pts) What is the value of \( \Delta(\Delta G^\circ) \) for the above equilibrium given the following A-values for the monosubstituted (X) cyclohexane: \( X = \text{Cl} = 0.5 \text{ kcal/mol}; X = \text{CH}_3 = 1.8 \text{ kcal/mol}; X = \text{C}_2\text{H}_5 = 1.9 \text{ kcal/mol} \)? **Show calculations.**

Chair A energy = ____________  
Chair B energy = ____________
3. **Potpourri**: (25 pts.; equal weight) **Circle** the best answer(s) where applicable in each of the following:

a) **Estimate** the difference in the heat of combustion and heat of formation in kcal/mol for cis- and trans-1,4-dimethylcyclohexane. **Explain briefly.**

b) **Circle** the “acids” that are readily deprotonated by n-butyllithium (n-CH₃CH₂CH₂CH₂Li).

   ethanol  CH₃CO₂H  NH₃  NH₄⁺  acetylene

c) **Circle** the species with sp² hybrid atoms.

   HCN  ethylene  CO₂  CH₂=CH₂  [BeCl₃]⁻

d) **Briefly** explain and illustrate why ClCH₂CH₂Cl has a net dipole while trans-CICH=CHCl does not. [Newman projections of the most stable conformations of 1,2-dichloroethane might be helpful.]

e) The following “acids” all have resonance stabilized conjugate bases. Rank these acids (low pKa to high pKa) with the numbers 1 – 5, respectively. [Most acidic gets number 1.]
4. **Thermochemistry:** (20 pts.) n-Heptane ($\Delta H_f^\circ = -44.8 \text{ kcal/mol}$) and 2-methylhexane ($\Delta H_f^\circ = -46.6 \text{ kcal/mol}$) both have the formula $\text{C}_7\text{H}_{16}$.

a) (5 pts.) What type of isomers are they?

b) (5 pts.) What is the difference in their heats of combustion?

c) (10 pts.) Prove part b) with a “Standard State” illustration of the combustion of the two isomers. [Your diagram should show the products of combustion and the number of moles of each.] Write an equation for the heat of combustion of n-heptane using its heat of formation.
5. **Bonding/Orbitals:** (15 pts) The “planar” compound 1 has a dipole moment. **Explain** and **illustrate** with an orbital diagram how this is possible.

![Orbital Diagram](image.png)
Periodic Table
Name: ______________________________________

Work Sheet
Work Sheet