first name  middle initial  last name

Student ID Number

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Your answers to this exam are to be only your own work. You may use no written information or electronic devices during this test period other than the nine pages of this exam. You may not use the back of any pages for answers. You may submit your exam for regrading if and only if you have made NO marks on the exam except for a star (*) ON THIS PAGE next to the number(s) of the question(s) you would like regarded and your signature(s) and check(s) below. Exams must be placed in the drop box in Pacific Hall, sixth floor not later than 5pm March 30th.

your signature (read the above before signing)

To request regrading, sign below and check the appropriate boxe(s).

your signature

I would like the questions marked with a star (*) regraded (check box at right)

If you feel that we have made an addition error in your score, check the box at the right

If you believe your grade was recorded incorrectly on TED, check the box at the right

b
The absorption in the infrared at 1720 is indicative of the presence of a:

- Carbonyl group
- Alcohol
- Amine
- Nitrile

The contribution of a C–C bond is:

- 146 kcal/mole
- 99 kcal/mole
- 63 kcal/mole
- 86 kcal/mole

The reduction of a simple C=C \pi bond is:

- is exothermic by 63 kcal/mole
- is endothermic by 63 kcal/mole
- is exothermic by 30 kcal/mole
- is endothermic by 30 kcal/mole

The difference in energy between 1-butene and trans-2-butene is:

- 1.0 kcal/mole
- 2.7 kcal/mole
- 1.7 kcal/mole
- 0.9 kcal/mole

The correct order of stability of carbocations is:

- 1\textsuperscript{+}>2\textsuperscript{+}>3\textsuperscript{+}
- 2\textsuperscript{+}>3\textsuperscript{+}>1\textsuperscript{+}
- 3\textsuperscript{+}>2\textsuperscript{+}>1\textsuperscript{+}
- 2\textsuperscript{+}>1\textsuperscript{+}>3\textsuperscript{+}

The methyl group of an ethyl group [CH\textsubscript{3}CH\textsubscript{2}—] will appear in the proton NMR as a:

- singlet
- triplet
- doublet
- quartet

The maximum splitting of a methylene group an ethyl group [CH\textsubscript{3}CH\textsubscript{2}—] in a molecule with more than 3 carbon atoms is a:

- quintet
- sextet
- triplet
- quartet

Your signature (in ink)_________________________________________
At equilibrium, two compounds that differ in energy by 4.1 kcal/mole will be in a ration of approximately:

☐ 1:1
☐ 100:1
☒ 1000:1

The contribution of a C–O bond is:

☐ 146 kcal/mole
☐ 99 kcal/mole
☒ 86 kcal/mole
☒ 63 kcal/mole

(any answer counted as correct)

The correct average bond energies for the pi and sigma bonds between carbon and oxygen in the following compounds is:

\[
\begin{array}{c}
\text{C} \\
\text{O} \\
\text{H} \\
\text{H} \\
\end{array}
\]

☐ 173
☒ 179
☐ 176
☒ 173
☐ 179
☒ 176

In electrophilic, aromatic substitution, a bromine substituent on a benzene ring is:

☐ Activating, o,p directing
☐ Activating, m directing
☒ Deactivating, o,p directing
☒ Deactivating, m directing

In electrophilic, aromatic substitution, a nitro group on a benzene ring is:

☐ Activating, o,p directing
☐ Activating, m directing
☒ Deactivating, o,p directing
☒ Deactivating, m directing

In electrophilic, aromatic substitution, an alkyl group on a benzene ring is:

☒ Activating, o,p directing
☐ Activating, m directing
☐ Deactivating, o,p directing
☒ Deactivating, m directing

In electrophilic, aromatic substitution, an acyl group on a benzene ring is:

☐ Activating, o,p directing
☐ Activating, m directing
☐ Deactivating, o,p directing
☒ Deactivating, m directing
2. Show the mechanism for the formation of the active electrophile for each of the following electrophilic aromatic substitution reactions. Your mechanism must include curved arrows showing the flow of electrons for all bonds made and broken. Answers outside the provided boxes will not receive credit.

3. Shade the p orbitals in the diagrams below to depict the three molecular orbitals of an allylic radical. Indicate the number of electrons in each orbital in the boxes provided. If an orbital is empty, write 0. Indicate the orbitals as bonding, antibonding, and non-bonding, as appropriate.
4. Provide a complete mechanism including curved arrows showing the flow of electrons for all bonds made and broken for the following reaction. You may use H+ as the source of a proton and you need not show where a proton goes when it is lost.
5. Provide the expected major organic product from each of the following reactions. Do not show stereochemistry for products with only one center of chirality. If two centers are present in the product, you must show relative stereochemistry. You must place your answer in the box provided. Answers outside the boxes will not receive credit.
6. Provide the expected major organic product from each of the following reactions. Do not show stereochemistry for products with one center of chirality. If two centers are present in the product, you must show relative stereochemistry. You must place your answer in the box provided. Answers outside the boxes will not receive credit.
7. For each of the following reactions, provide two sets of reagents that could be used consecutively to convert the starting material to the product shown. Be very careful, the order of the two steps is important and simply reversing the two steps will result in a significant grade penalty. Your answers must be placed within the provided boxes.
8. Provided below is the proton NMR spectrum of an unknown. Propose a structure consistent with the spectrum. Your answer must be placed inside the box provided.

\[ C_6H_{14}O \]

\[ \text{HO} \]

\[ \text{HO-CH}_2^+ \]

\[ \text{PPM} \]

9. Propose a sequence of reactions that could be used to prepare the alcohol shown below from any combination of reagents, none of which has more than two carbon atoms. Your answer must fit completely inside the box provided.

Your signature (in ink) ____________________________________________