Answer Key

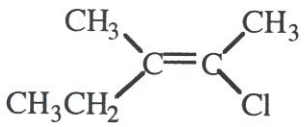
C. F. Bernasconi **Chemistry 108A** **Winter 2009**

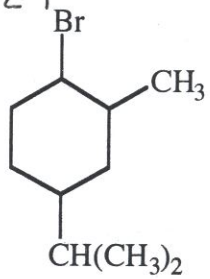
First Midterm Exam – February 3, 2009

This exam consists of eleven (11) questions for a total of 100 points. Try to answer all questions. Write your answers in a Blue Book. Put your name and your TA's name on the front page of the Blue Book.

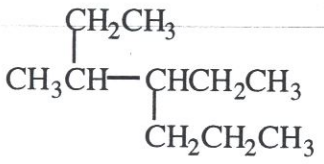
1. (*9 points*) Give IUPAC names for the following compounds.

Z-2-chloro-3-methyl-2-pentene

(a) 

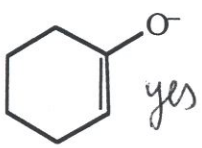
(b) 

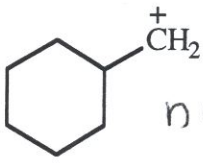
1-bromo-4-isopropyl-2-methylcyclohexane

(c) 

4-ethyl-3-methylheptane

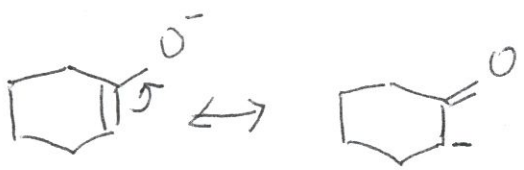
2. (*12 points*) Some of the species shown below represent a resonance structure. Identify those species and draw as many alternative resonance structures as possible. Using curved arrows, show how the different resonance structures can be interconverted into each other.

(a) 
yes

(b) 
no

(c) $CH_2{=}CH{-}CH{=}CH{-}\overset{+}{C}HCH_3$
yes

(d) $CH_3\bar{C}H{-}\overset{+}{N}(=O)O^-$
yes

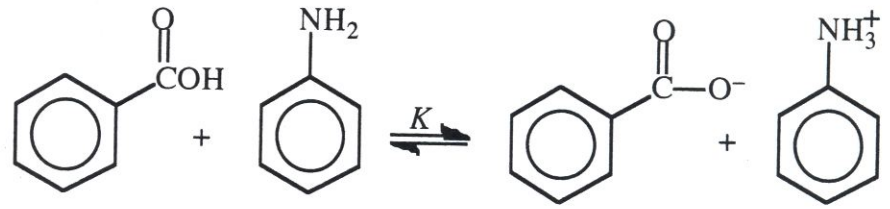
(a) 

(c) $CH_2{=}CH{-}CH{=}\overset{\curvearrowright}{CH}{-}\overset{+}{C}HCH_3 \longleftrightarrow CH_2{=}\overset{\curvearrowright}{CH}{-}\overset{+}{C}H{-}CH{=}CHCH_3$

$\leftrightarrow$ $^{+}CH_2-CH=CH-CH=CHCH_3$

(d) $CH_3\bar{C}H-\overset{+}{N}(=O)-O^- \leftrightarrow CH_3CH=\overset{+}{N}(-O^-)-O^- \leftrightarrow CH_3\bar{C}H-N(=O)-O^-$

(3) (*10 points*) Consider the following acid-base equilibrium.



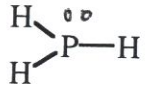
$pK_a = 4.5$ $pK_a = 5.5$

(a) Based on the given pK_a values of the two acids, would you expect that the equilibrium favors the product side or the reactant side? Favors products

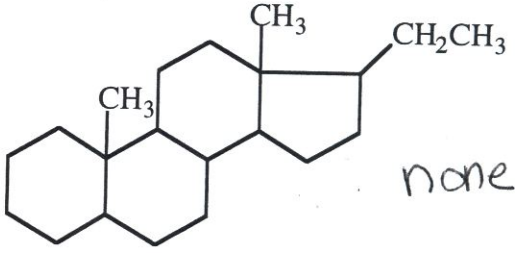
(b) Caclulate the equilibrium constant K of the reaction. $K = K_a^{PhCOOH} / K_a^{PhNH_3^+} = 10^{-4.5} / 10^{-5.5} = 10$

(c) Is ΔG^o positive or negative?

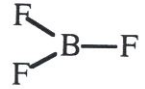
(4) (*12 points*) Which of the following species are Brønsted-Lowry acids, Lewis acids, bases, or none of the above?

(a) 

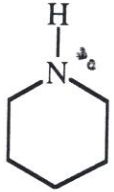
Base

(b) 

none

(c) 

Lewis acid

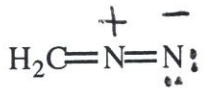
(d) 

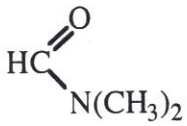
Base

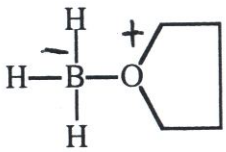
(e) $CH_3CH_2\overset{+}{O}(H)CH_2CH_3$ Bronsted-Lowry acid

(f) Mg^{2+} ← Lewis acid

5. (*9 points*) Which of the following neutral molecules have formal charges on some of their atoms? Show the charges.

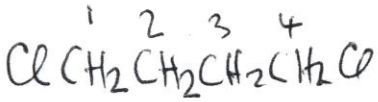
(a) 

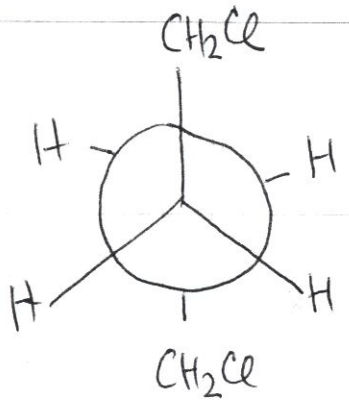
(b) 

(c) 

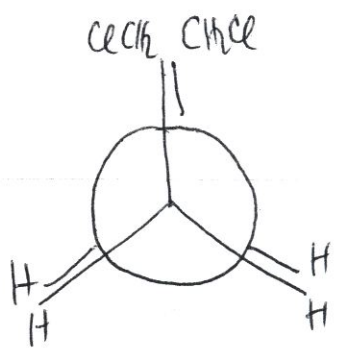
none

6. (*6 points*) Draw Newman projections of the most stable and the least stable conformation of 1,4-dichlorobutane. In drawing the Newman projection, look down the C_2–C_3 bond.



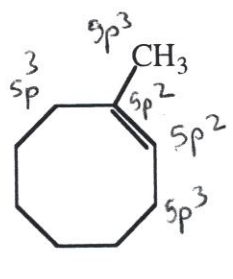


most stable



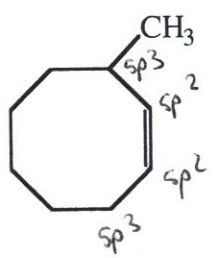
least stable

7. (*10 points*) It turns out that there are two factors that render one of the two alkenes more stable than the other. Which is the more stable alkene and what are the two factors?



more stable

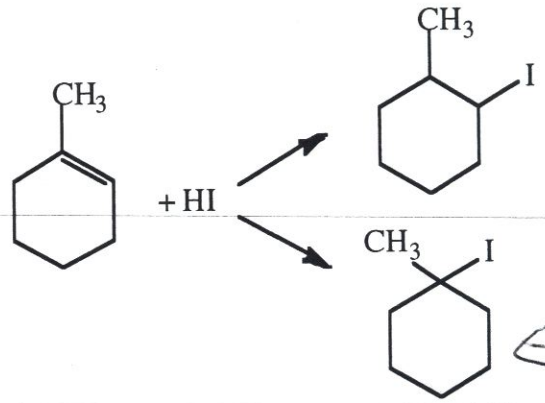
has three sp^3–sp^2 bonds

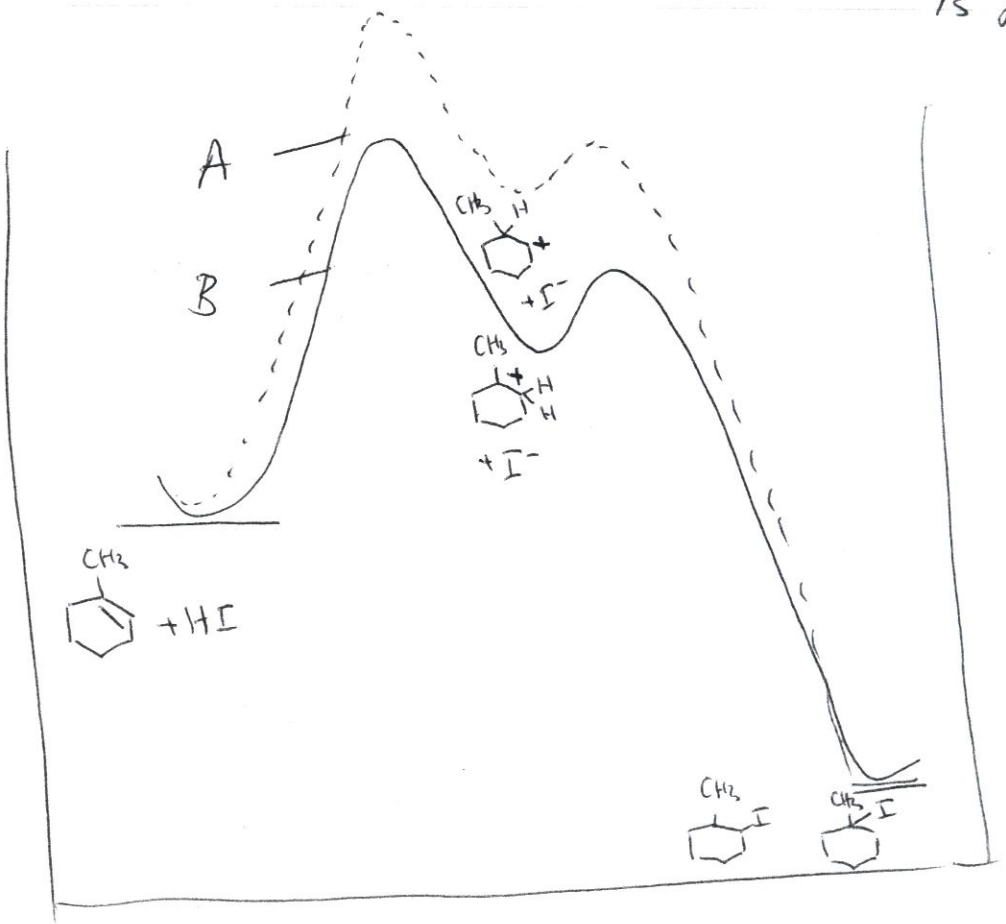


less stable, has only two sp^3–sp^2 bonds

Also: first alkene has two CH_2 groups and one CH_3 group which can engage in hyperconjugation with the double bond while

8. (*12 points*) The addition of HI to 1-methylcyclohexene may, in principle, lead to a mixture of two products as shown below. However, in practice, only one of the two products is formed. Which is the product formed and why is it the one being formed? Explain in some detail making use of a reaction-energy diagram.





The carbocation intermediate leading to product B is more stable (3° cation) than the one leading to product A (2° cation) and hence the transition state for path B is lower in energy than the one for path A.

9. (*8 points*) Is the following reaction exothermic or endothermic? You can answer this question if you know the bond dissociation energies of the C–H bond (438 kJ/mol), C–I bond (234 kJ/mol), the I–I bond (151 kJ/mol) and the H–I bond (298 kJ/mol) and calculate ΔH° for the reaction.

$$CH_3CH_3 + I_2 \longrightarrow CH_3CH_2I + HI$$

$CH_3-CH_2|H + I|I \longrightarrow CH_3CH_2|I + H|I$

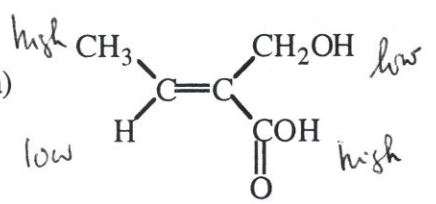
438 151 234 298

589 (total) 532 (total)

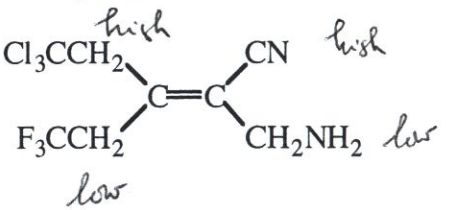
$\Delta H^{\circ} = -532 + 589 = 57$

Reaction is endothermic and hence will not happen.

10. (*6 points*) Assign *E* or *Z* configurations to the following alkenes.

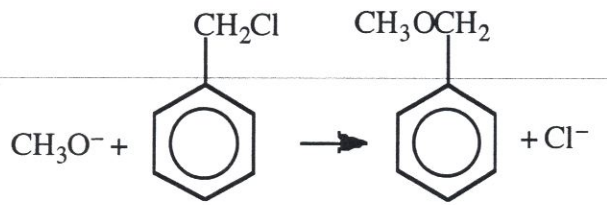
(a) 

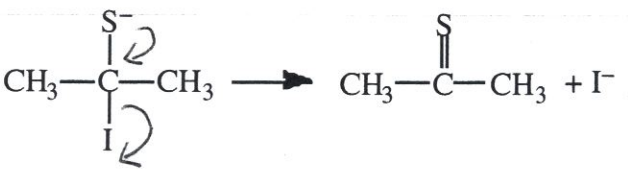
E

(b) 

Z

11. (*6 points*) Add curved arrows to the following reactions to indicate the flow of electrons in each:

(a) 

(b) 

(c)