

CHEM 3311 (Richardson) First Hour Exam - September 25, 2012

Your Name Key

Student ID No. _____

Recitation Day/Time _____

Recitation TA (circle one) Thomas Carey, Adam Csakai,
Jake Greenberg, Maria Kolber,
Tim Rochelle, Mike Springer

Question	Score	Out of
1		20
2		15
3		20
4		20
5		5
6		10
7		5
8		5
Total		100

This is a closed-book exam. The use of notes, calculators, scratch paper, or cell phones will not be allowed during the exam. You may use models brought in a clear ziplock bag. Use the backs of the pages for scratch work. Please put all your answers on the test in pen, not pencil.

hydrogen 1 H 1.0079	helium 2 He 4.0026																	
lithium 3 Li 6.941	beryllium 4 Be 9.0122																	
sodium 11 Na 22.98976928	magnesium 12 Mg 24.304																	
potassium 19 K 39.0983	calcium 20 Ca 40.078	scandium 21 Sc 44.955912	titanium 22 Ti 47.88	vanadium 23 V 50.9415	chromium 24 Cr 51.9961	manganese 25 Mn 54.938044	iron 26 Fe 55.845	cobalt 27 Co 58.933195	nickel 28 Ni 58.6934	copper 29 Cu 63.546	zinc 30 Zn 65.38	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.9216	selecnium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	
rubidium 37 Rb 85.4678	strontium 38 Sr 87.62	yttrium 39 Y 88.90584	zirconium 40 Zr 91.224	niobium 41 Nb 92.90638	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.6	iodine 53 I 126.905	xenon 54 Xe 131.29	
cesium 55 Cs 132.91	barium 56 Ba 137.33	* 57-70	lanthanum 57 La 138.905	hafnium 72 Hf 178.49	tantalum 73 Ta 180.948	wolfram 74 W 183.84	reynoldsium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	* *	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	esboium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]		

* Lanthanide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	esboium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

** Actinide series

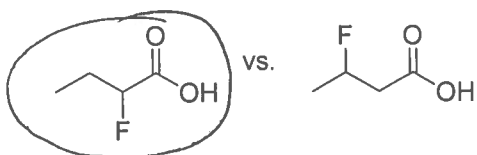
pKa Values

HI	-10.1	H ₂ O	15.7
HCl	-3.9	Alcohol (ROH)	16-18
H ₃ O ⁺	-1.7	HC≡CH	26
CH ₃ COOH	4.7	NH ₃	36
NH ₄ ⁺	9.3	H ₂ C=CH ₂	45
Phenol	10	CH ₄	60

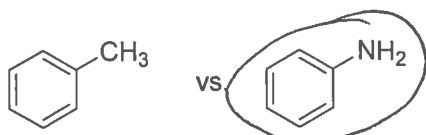
Average = 72.6
St Dev = 13.0
Max = 98.5
Min = 31.5

1) Acids and bases (20 pts)

- a. For each pair of compounds shown below, select the more acidic of the two compounds and explain your reasoning. (8 pts) (1 pt per circle, 2 pt per reason)



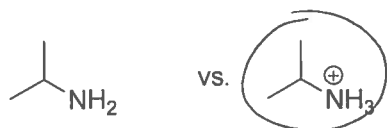
Reason: Stronger inductive effect stabilizes the \ominus charge better, since the electron-withdrawing group is closer.



Reason: C & N are in same row of periodic table, so more electronegative atom (N) = more acidic.



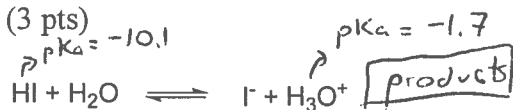
Reason: N & P are in same column of periodic table, so larger atom (P) = more acidic.



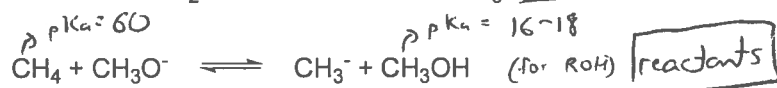
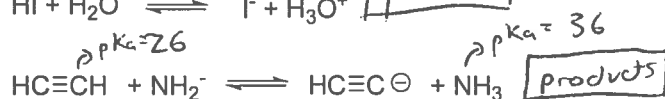
Reason: -NH_3^+ has a positive charge & can more easily lose an H^+

- b. For each of the following reactions, does the equilibrium favor the reactants or products?

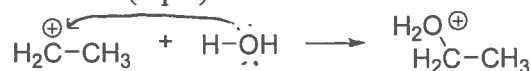
(3 pts)



(2 pt each)



- c. Complete each arrow-pushing mechanism and identify the HOMO and LUMO of each reaction. (9 pts)

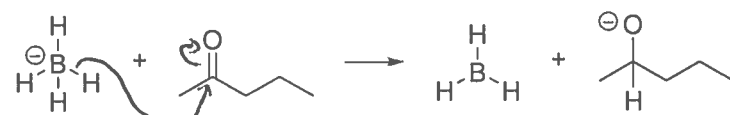


(1 pt for arrows, 1 for HOMO, 1 for LUMO)

HOMO: nb on O (lone pair)
LUMO: nb on C (empty p orbital)



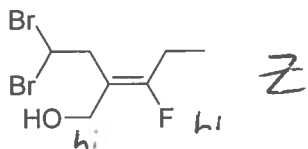
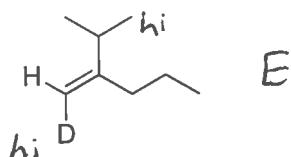
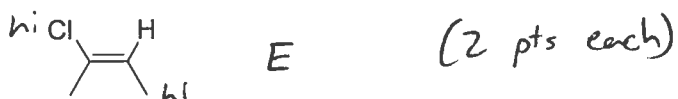
HOMO: C-C π
LUMO: H-Br σ^*



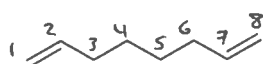
HOMO: B-H σ
LUMO: C-O π^*

2) Alkene naming and stereoisomers (15 pts)

a. Assign an E or Z descriptor to the following molecules. D is deuterium, an atom with the same atomic weight as hydrogen, but with an atomic weight of 2 instead of 1. (6 pts)

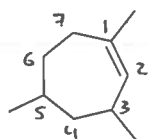


b. Name the following structures. Include E/Z descriptors where appropriate. (6 pts)

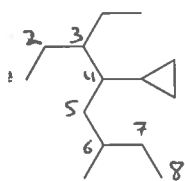


Name: 1,7-octadiene

(2 pts each; -0.5 for E/Z, numbering, & alphabetizing wrong)



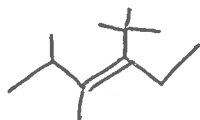
Name: (Z)-1,3,5-trimethyl-1-cycloheptene



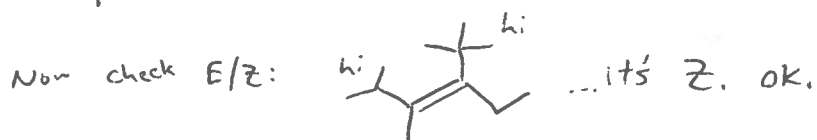
Name: 4-cyclopropyl-3-ethyl-6-methyloctane

c. Draw the structure of (Z)-4-tert-butyl-2,3-dimethyl-3-hexene. (3 pts)

Draw connectivity first, ignoring E/Z:



Now check E/Z:

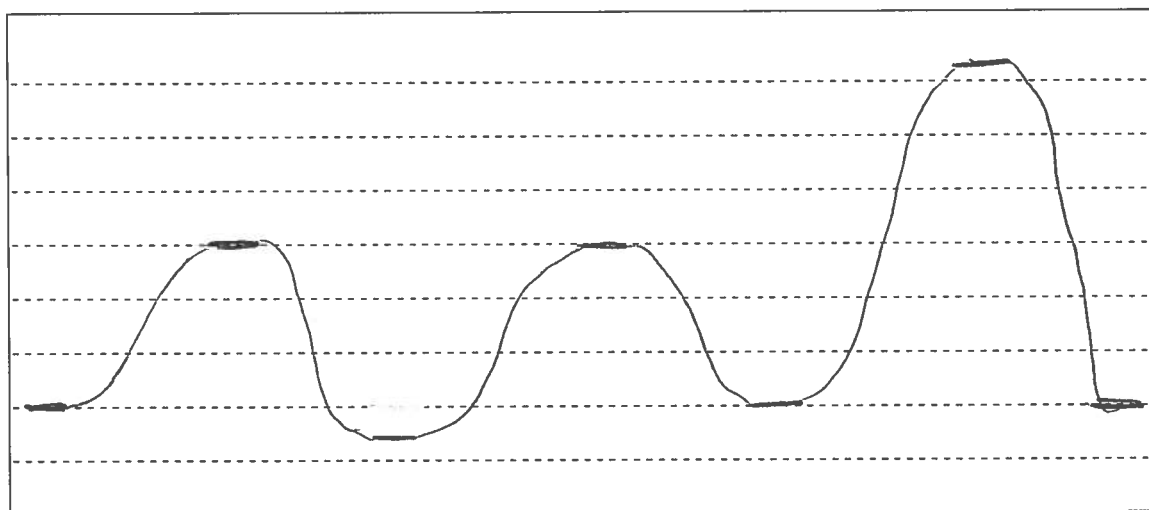
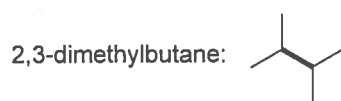


(-1 pt for E isomer.)

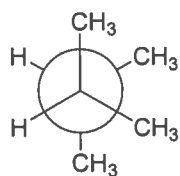
- 3) The structure of 2,3-dimethylbutane is shown below. Sighting along the C2-C3 bond (shown in bold), show a Newman projection for the molecule for dihedral angles in increments of 60° . **Keep the front atom stationary and rotate the back atom clockwise.** For each conformation, plot these energy levels and create a conformational energy diagram. You do not need to calculate the exact energy for each level – a rough estimate is acceptable. (20 pts)

Interaction	Energy (kcal/mol)
H/H eclipsed	1
CH ₃ /H eclipsed	1.15
CH ₃ /CH ₃ eclipsed	3.6
CH ₃ /CH ₃ gauche	0.67

(-2 for ignoring bolded sentence)

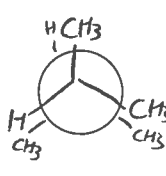


(8 pts)



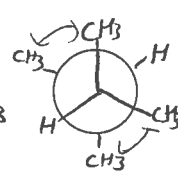
Interactions:

3 x
CH₃/CH₃
gauche



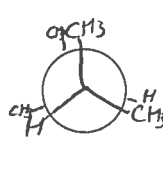
Interactions:

2 x CH₃/H
eclipsed
1 x CH₃/CH₃
eclipsed



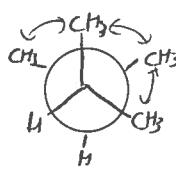
Interactions:

2 x
CH₃/CH₃
gauche



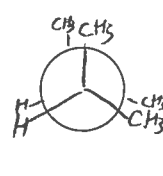
Interactions:

2 x CH₃/H
eclipsed
1 x CH₃/CH₃
eclipsed



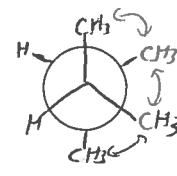
Interactions:

3 x CH₃/CH₃
gauche



Interactions:

2 x CH₃/CH₃
eclipsed
1 x H/H
eclipsed



Interactions:

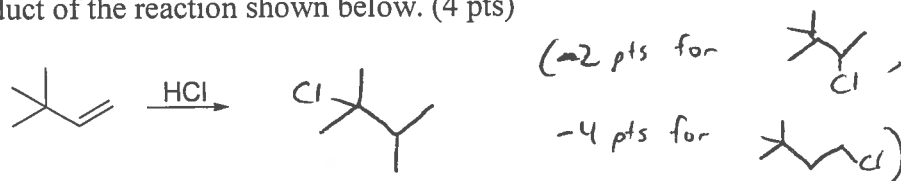
3 x CH₃/CH₃
gauche

(1 pt each)

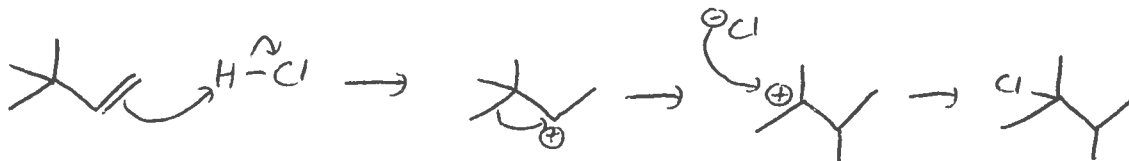
(1 pt each)

4) Additions to alkenes (20 pts)

a. Predict the major product of the reaction shown below. (4 pts)



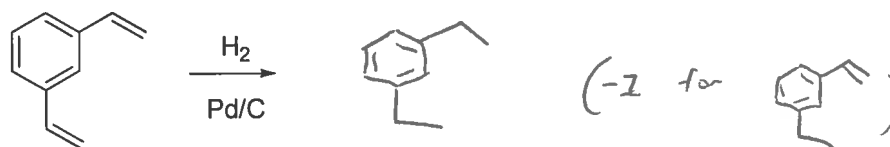
b. Write an arrow-pushing mechanism for this reaction. Show all intermediates including correct formal charges, but do not show transition states. (10 pts)



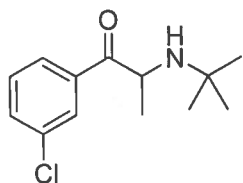
2° carbocation rearranges to 3° carbocation.

(-5 pts for no methyl shift; -1 pt for each missing/incorrect arrow)

c. Predict the products of the following reactions. (6 pts) (2 pts each)



5) Wellbutrin, shown below, is an antidepressant and smoking cessation aid. Which of the listed functional groups does Wellbutrin contain? Circle all that apply. (5 pts)



(-2 pt for each incorrect circle / lack of circle)

Aldehyde

Ketone

Amide

Amine

Aromatic Hydrocarbon

Alkyne

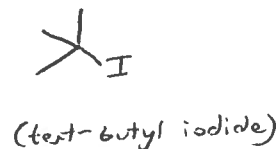
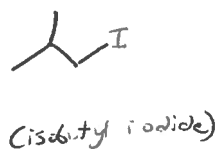
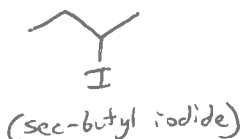
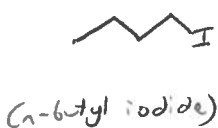
Alcohol

Ester

Nitrile

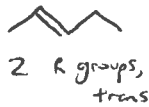
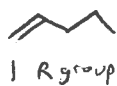
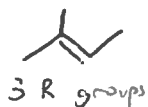
Carboxylic Acid

6) Draw all the constitutional isomers with formula C_4H_9I , using bond-line structures. Be careful not to repeat any structures. (10 pts)



(2.5 pts each)

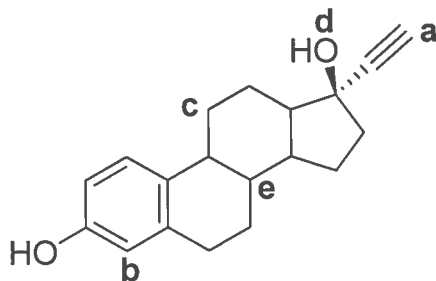
7) Put the following alkenes in order of stability, from most stable to least stable. 2-methyl-2-butene, 1-pentene, (E)-2-pentene, (Z)-2-pentene (5 pts)



most to least stable:

 2-methyl-2-butene, (E)-2-pentene, (Z)-2-pentene, 1-pentene

8) The structure of ethynyl estradiol, an oral contraceptive, is shown below. For each of the labeled atoms, describe the hybridization as sp , sp^2 , or sp^3 . (5 pts)



a = sp
 b = sp^2
 c = sp^3
 d = sp^3
 e = sp^3

(1 pt each)