Name Key Slayter Box 007

Examination II March 25, 2013

take-home portion

Organic Structure and Reactivity (CHEM 132-01)

Dr. Fantini

Instructions:

- This exam consists of *seven* questions.
- You may use your calculator to complete this exam.
- You may not use your notes, your text, the internet, your phone or any electronic resource other than your calculator while taking the exam.
- **You must complete the exam in one continuous block of time.** You may take as long as you need to write your answer to the questions below. There is no time limit.
- **This exam is due at the beginning of class on Wednesday, March 27th.**
- Write clearly and show all of your work.
- ***All work must be your own, and you must sign a pledge to this effect at bottom of this page. If you do not sign the pledge, you will receive no credit for the take home exam assignment.***

Academic Integrity Statement

I have followed all directions on the cover page of this exam. All work is my own, and I have neither given, nor received any help while completing this take home exam.
By signing below, I indicate my compliance with the above integrity statement.

Signature _____ Date _____

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Examination II

March 25, 2013

Instructions:

1) This exam consists of **7** problems.

2) Work that is not clear and legible will not be graded

3) Method and/or reasoning must be shown. No credit will be given for an answer alone.

4) Give units for all answers and use significant figures.

5) No books or notes are to be used.

6) Do not share calculators

Question	Possible	Score
1	20	
2	15	
3	19	
4	12	
5	14	
6	10	
7	10	
TOTAL	100	

201. The reaction shown below **(A)** is non-spontaneous.

(A) $Al_2O_3(s) \rightarrow 2\,Al(s) + {}^3/_2\,O_2(g)$ $\Delta G° = +1670$ kJ

In order to obtain aluminum (Al) from aluminum oxide (Al_2O_3), this reaction **(A)** could be combined with one of the reactions shown below.

(B) $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta G° = -394$ kJ

(C) $Mg(s) + {}^1/_2\,O_2(g) \rightarrow MgO(s)$ $\Delta G° = -601$ kJ

(D) $Si(s) + O_2(g) \rightarrow SiO_2(s)$ $\Delta G° = -911$ kJ

(a) Use Hess's law to write a new reaction that combines equation **(A)** with one of the other reactions **(B, C, D)** that fulfills the following two conditions:

(i) the new reaction is spontaneous. ← means has ⊖ $\Delta G°$

(ii) $O_2(g)$ is neither a reactant or a product in the new reaction. Note a reaction will have to be multiplied through by a constant factor to achieve this.

$Al_2O_3(s) \rightarrow 2\,Al(s) + {}^3/_2\,O_2(g)$ $\Delta G° = +1670$

$3\left(Mg(s) + {}^1/_2\,O_2(g) \rightarrow MgO(s)\right)$ $\Delta G° = (3)(-601) = -1803$

$Al_2O_3(s) + 3\,Mg(s) + {}^3/_2\,O_2(g) \rightarrow 2\,Al(s) + {}^3/_2\,O_2(g) + 3\,MgO(s)$

$Al_2O_3(s) + 3\,Mg(s) \rightarrow 2\,Al(s) + 3\,MgO(s)$

(b) What is $\Delta G°$ for the new reaction?

$\Delta G° = (1670 - 1803)$ kJ/mol

$\boxed{\Delta G° = -133 \text{ kJ/mol}}$

(c) Calculate K_{eq} for the new reaction from $\Delta G°$. Note: $\Delta G° = -RT\ln(K_{eq})$; $R = 8.31 \times 10^{-3}$ kJ/(K·mol)

$\Delta G° = -RT\ln K \rightarrow K = e^{\left(\frac{-\Delta G°}{RT}\right)}$

$K = e^{\left(\frac{133 \text{ kJ/mol}}{8.31\times10^{-3}\ \frac{kJ}{K\cdot mol}\ \cdot\ 298K}\right)}$

$K = 2.11 \times 10^{+23}$

152. The air pollutant NO is produced in automobile engines because of the high-temperature reaction between nitrogen and oxygen gas. At 2300 K, $K_c = 0.0017$. For a mixture of N_2, O_2 and NO with the following initial concentrations, what will be the equilibrium concentrations of all the species at 2300 K? $[N_2]_i = 1.2$ M; $[O_2]_i = 1.3$ M; $[NO]_i = 1.5$ M

$$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$$

$$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$$

$$K = \frac{[NO]_{eq}^2}{[N_2]_{eq}[O_2]_{eq}}$$

calculate Q to see which way to go to attain eq'm

$$Q = \frac{[NO]^2}{[N_2][O_2]}$$

$$Q = \frac{(1.5)^2}{(1.2)(1.3)} = 1.44 \Rightarrow Q > K$$

Reaction will shift backwards to reactants.

5 pts

	$N_2(g)$	+ $O_2(g)$	$\rightleftharpoons$ $2\,NO(g)$
I	1.2	1.3	1.5
C	+x	+x	−2x
E	(1.2+x)	(1.3+x)	(1.5−2x)

$$K = \frac{(1.5-2x)^2}{(1.2+x)(1.3+x)}$$

$$K = \frac{4x^2 - 6x + 2.25}{x^2 + 2.5x + 1.56}$$

$$0.0017 = \frac{4x^2-6x+2.25}{x^2+2.5x+1.56}$$

$$0.0017x^2 + 0.00425x + 0.002652 = 4x^2 - 6x + 2.25$$

$$3.9983x^2 - 6.00425x + 2.2473 = 0$$

Solve quadratic eq'n

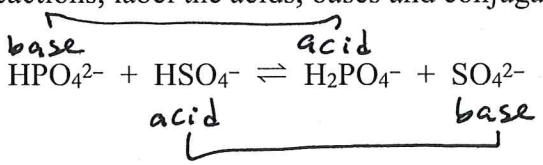
$x = 0.79$ ← gives a negative value for [NO]

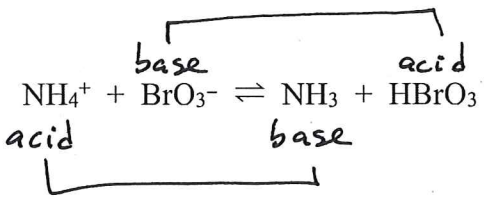
$x = 0.71$ ← the soln for x

$[N_2]_{eq} = 1.9$ M ; $[O_2]_{eq} = 2.0$ M ; $[NO]_{eq} = 0.1$ M

193. Acid–base questions.

(a) In each of the following reactions, label the acids, bases and conjugate acid-base pairs.





(b) Write a balanced equation for the reaction of each of these Brønsted-Lowry **bases** with water ***and*** write the K_b expression that goes with the chemical equation.

benzoate ion, $C_6H_5COO^-$

$$C_6H_5COO^- + H_2O \rightarrow C_6H_5COOH + OH^-$$

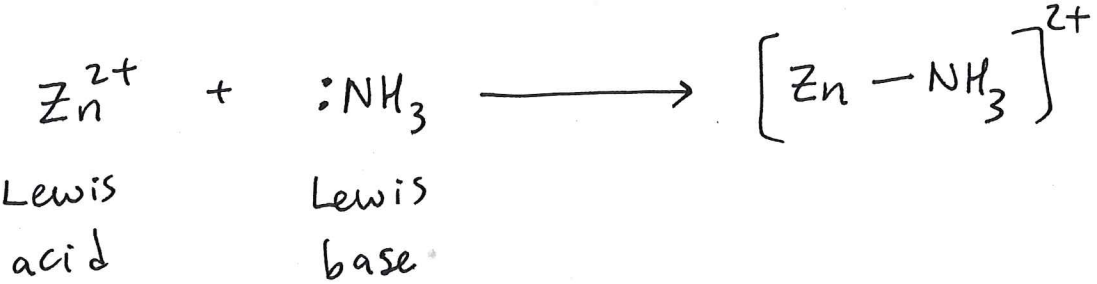
$$K_b = \frac{[C_6H_5COOH][OH^-]}{[C_6H_5COO^-]}$$

$H_2AsO_4^-$

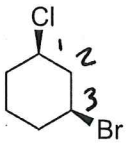
$$H_2AsO_4^- + H_2O \longrightarrow H_3AsO_4 + OH^-$$

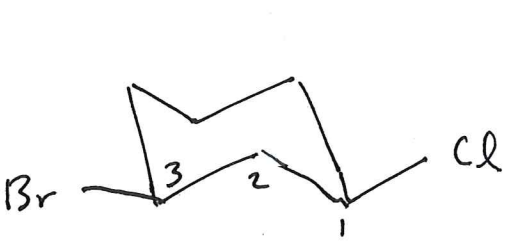
$$K_b = \frac{[H_3AsO_4][OH^-]}{[H_2AsO_4^-]}$$

(c) The reaction between Zn^{2+} and NH_3 is explained by Lewis acid-Lewis base theory. Write the equation for **one** Zn^{2+} ion reacting with **one** NH_3 molecule using Lewis dot formulas. Which is the Lewis base? Which is the Lewis acid?

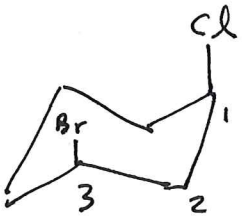


124. Please draw both chair conformers of the molecule shown. Use the chair convention for your drawing and don't have any dashes or wedges on it—let the direction of lines speak for themselves. Also, ***identify which is the more stable conformer.***





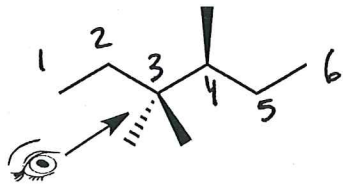
ring flip →

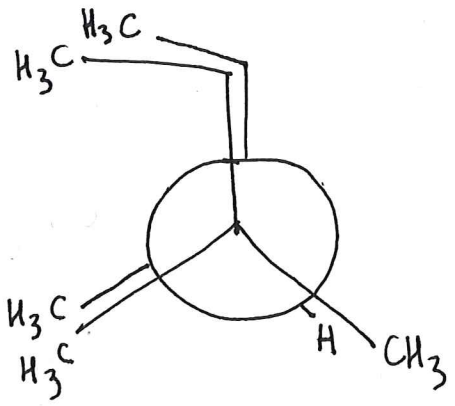


more stable conformer

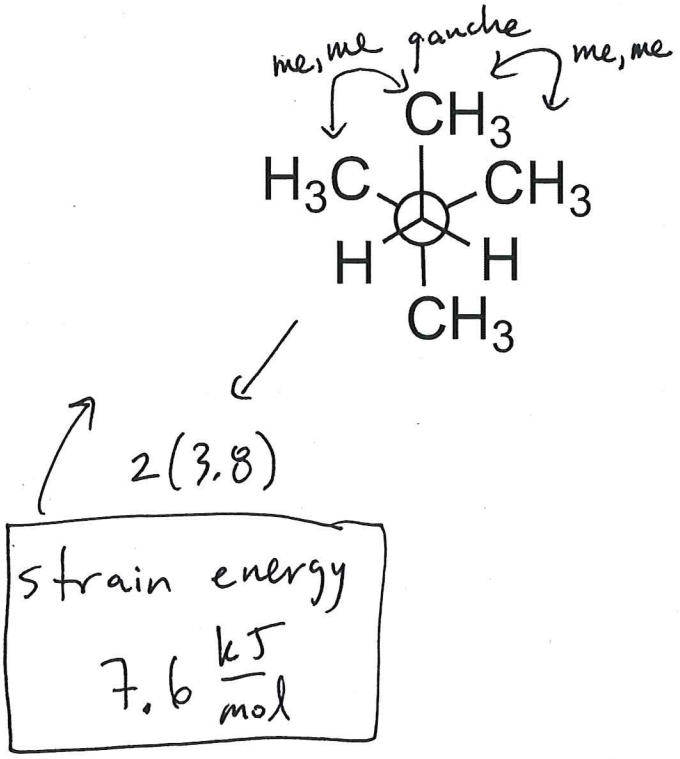
145. Questions about acyclic alkanes.

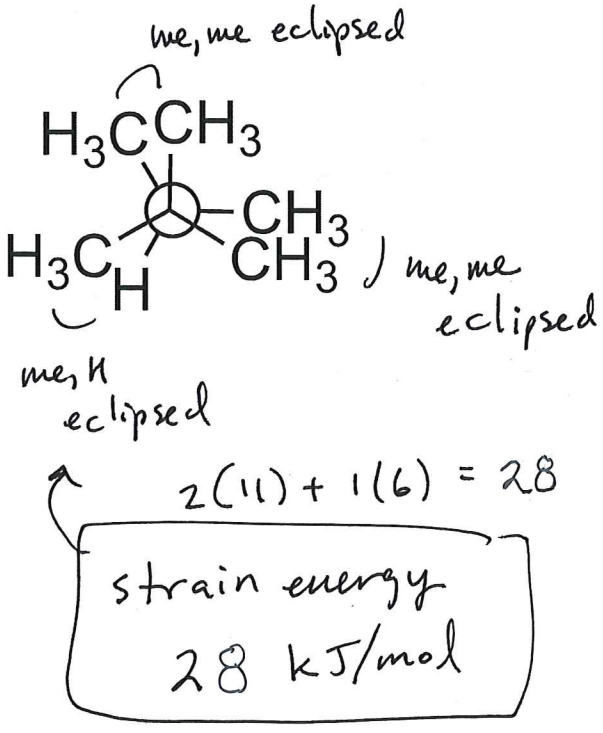
(a) Draw a Newman projection down the C(3)—C(4) bond of this compound (an eyeball and arrow are pointing at it) that shows the ***least stable conformation*** of the following alkane. Put C(3) in the front and C(4) in the back.





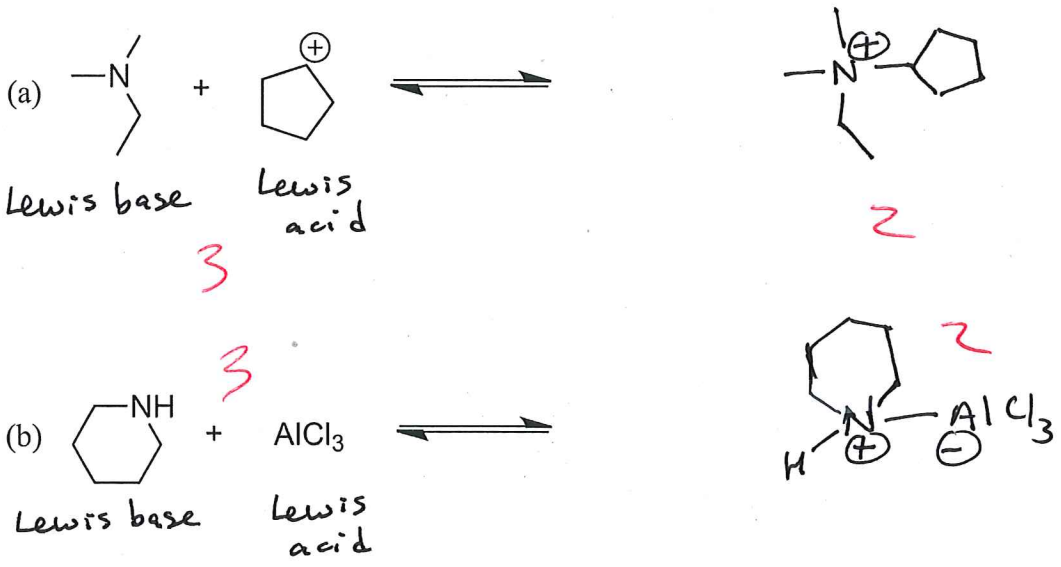
(b) Calculate the strain energy in each of the following compounds. (The first is ***staggered*** and the second is ***eclipsed***.) ** ***Component strain energies are listed at the bottom right of the page.*** **





Type of interaction	kJ/mol
H,H eclipsing	4.0
H,CH_3 eclipsing	6.0
CH_3,CH_3 eclipsing	11
CH_3,CH_3 gauche	3.8

106. Identify the Lewis acid and Lewis base in each reaction. Draw the Lewis acid–base adduct as the product.



107. Explain which of ethanol (CH_3CH_2OH) or ethaneselenol (CH_3CH_2SeH) is the stronger acid by using principles for determining stability of bases. Be sure to explain and justify your choice. Restating definitions or the given information alone is not an explanation.

The two bases are $CH_3CH_2O^{\ominus}$

$CH_3CH_2Se^{\ominus}$

They differ as to what <u>element</u> holds the negative charge.

Selenium (Se) is under oxygen (O); it is much bigger than O and so will be better able to hold a negative charge.

weaker base: $CH_3CH_2Se^{\ominus}$

stronger base: $CH_3CH_2O^{\ominus}$

And thus the acid strength ranking is

CH_3CH_2SeH stronger acid than CH_3CH_2OH

McQuarrie's Solubility Rules

apply in this order

1. Most alkali metal salts and ammonium salts are soluble.
2. Most nitrates, acetates, and perchlorates are soluble.
3. Most silver, lead, and mercury(I) salts are insoluble.
4. Most chlorides, bromides, and iodides are soluble.
5. Most carbonates, chromates, sulfides, oxides, phosphates, and hydroxides are insoluble, except for hydroxides of Ba^{2+}, Ca^{2+}, and Sr^{2+}, which are slightly soluble.
6. Most sulfates are soluble, except for calcium sulfate and barium sulfate, which are insoluble.

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Uun (269)	111 Uuu (272)	112 Uub (277)						

Lanthanides	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinides	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)