

**Chemistry 3A - Spring 2000
Midterm 1**

Professor Jean Fréchet

February 16, 2000

Your full signature _____

Print your full name _____

(Last name, First name, Middle)

Your SID _____

Please check the section number and name of your GS/TA.

___ 161 Verdugo, Dawn

___ 171 Klopp, John

___ 181 Borths, Christopher

___ 191 Furdala, Kyle

___ 111 Watkins, Gregory

___ 121 Blackwell, Bethany

___ 131 Fox, Daniel

___ 141 Werkema, Evan

___ 261 Peterka, Darcy

___ 271 Lee, Charles

___ 211 Tripp, Jennifer

___ 221 Padilla, Omayra

___ 361 Haman, Kristina

___ 371 Hecht, Stefan

___ 311 Saxon, Eliana

___ 321 Cook, Brian

___ 461 Purdy, Matthew

___ 471 Evans, John

___ 411 Holland, Andrew

___ 421 Duncan, Andrew

___ 431 Trimble, Alexander

___ 511 Marcaurette, Lisa

521 Jen, Wendy

___ 531 Ling, Frank

If you are making up an I-grade, indicate the semester you took 3A _____ and the Professor _____.

This exam has 10 pages; **make sure that you have them all.** We will only grade answers that are in the designated spaces. Please do your scratch work on the backs of the exam pages. Write only **one** answer to each problem; multiple answers will receive **no** credit, even if one of them is correct.

Note: This examination runs for a total of 90 minutes. No questions will be answered by proctors after the exam begins. Please write legibly; ambiguous or messy answers will receive **no credit**.

A partial periodic table and data needed for calculations can be found on page 10 of the exam.

Do Not Write in this Box.

1. _____ (13)

2. _____ (16)

3. _____ (11)

4. _____ (13)

5. _____ (12)

6. _____ (12)

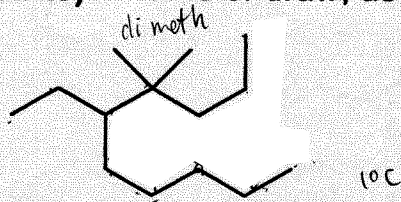
7. _____ (12)

8. _____ (11)

Total _____ (100)

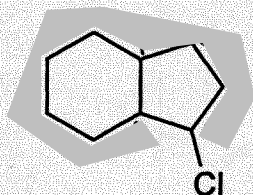
1. (13 points) Name or draw, as appropriate, the following molecules.

a.



(use IUPAC rules of nomenclature)

b.



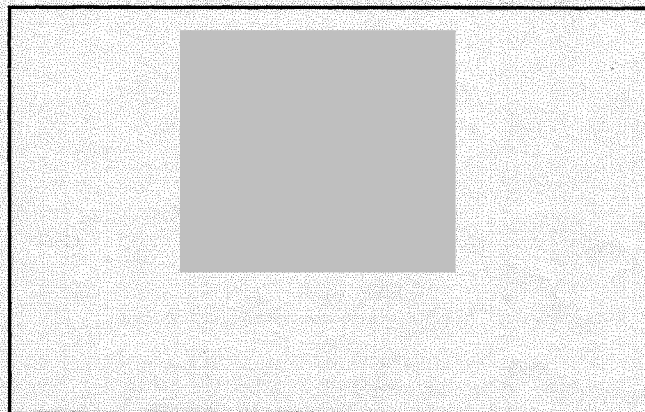
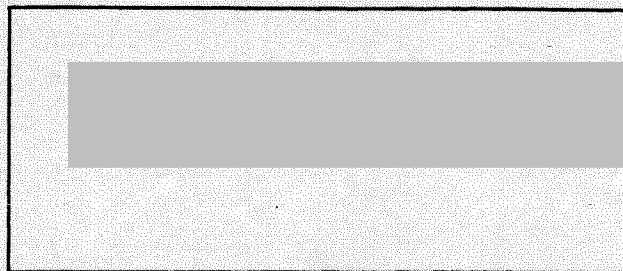
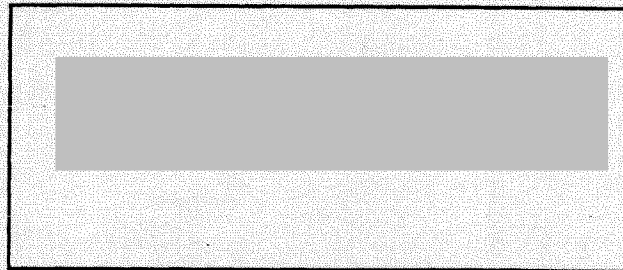
(use IUPAC rules of nomenclature)

c. cis-3,4-dichloro-1,1-dimethylcyclohexane
(chair form, use the template provided)

d. Acetic acid

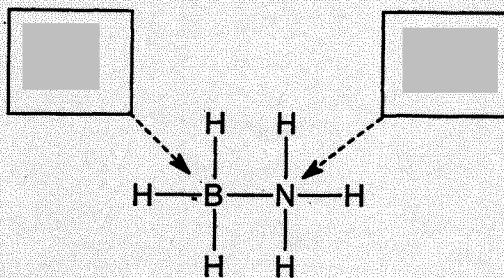


e. 1,6-dimethylspiro[4.5]decane



2. (16 points)

- 2a. Calculate the formal charge on each of the atoms indicated by an arrow in the structure below. Write the answer in the appropriate box (do not forget the sign!)

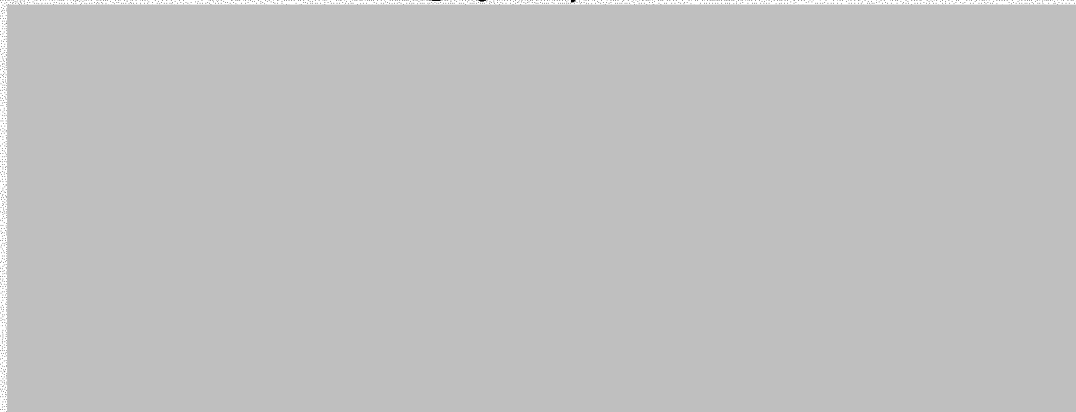


- 2b. Use Lewis-dot and all appropriate arrow notations to write all the major resonance forms for the NITRATE anion $[\text{NO}_3]^{-1}$ (**Hint:** in at least one of the structures, the nitrogen atom is surrounded by three oxygen atoms and the sum of all formal charges in this ion is -1. Do not forget to use curved arrows to show the movement of electrons.)

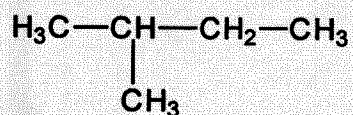
- 2c. For each of the structures below write **one** plausible resonance form. Use curved arrows to show the movement of electrons.

3. (11 points)

- 3a. Draw a **sawhorse** projection of the **gauche** conformation of butane $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
(As seen along the central $\text{C}_2\text{-C}_3$ bond)



- 3b. Draw a **Newman** projection of the **most stable** conformation of 2-methylbutane as seen along the $\text{C}_2\text{-C}_3$ bond

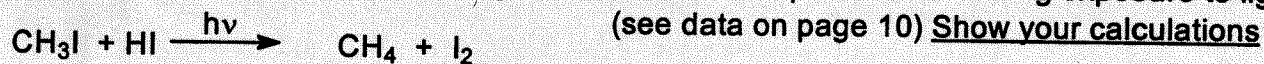


- 3c. Write clear structures for all of the monochlorinated products (containing 5 C atoms) that can be obtained by free-radical chlorination of 2-methylbutane. **Circle** the major product.



4. (13 points)

(4a) Calculate ΔH° for the following reaction that takes place under strong exposure to light.



Answer: $\Delta H^\circ =$

(4b) Write an equation for the initiation step for the radical chain reaction above

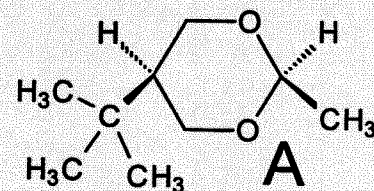
(4c) Write the propagation steps for the radical chain reaction of part 4a above

(4d) Consider the equilibrium below for which the equilibrium constant is 0.4. Write an equation for the equilibrium constant and calculate the percentage of butane gauche conformer at equilibrium. Show the details of your calculation.



Answer:

5. (12 points) (a) Draw the two chair conformations for compound A. Surprisingly, the equilibrium between these conformations favors that with the *t*-butyl group *axial*. Compare the two structures and explain clearly (with words and energy values) the reasons for this unexpected finding.



(b) Draw all the possible isomers of 1,2-dichlorocyclohexane showing all the chair conformations they may adopt. Circle the conformer you would expect to have the smallest dipole moment.

6. (12 points) (a) Draw a clear structure showing all orbitals of the methyl anion. What is the shape of the anion? What is the hybridization of C in this anion? What is the value of the H-C-H bond angle? (Hint: Use VSEPR)

Shape: Hybridization: H-C-H bond angle:

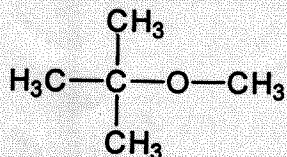
(b) Singlet methylene $:\text{CH}_2$ is an unusual moiety in which the two non-bonding electrons are paired in a single orbital. Draw a clear structure of singlet methylene showing all orbitals. What is the shape of the molecule? What is the hybridization of C? What is the value of the H-C-H bond angle? (Hint: Use VSEPR)

Shape: Hybridization: H-C-H bond angle:

(c) Write the electronic configuration for Silicon (Si, $Z = 14$)

Answer:

7. (12 Points) (a) The fuel additive MTBE has the formula given below. Calculate how many grams of oxygen would be required for the complete combustion of 8.8 grams of MTBE. (C = 12.0; H = 1.00; O = 16.0). Show a balanced equation and the details of your calculation.



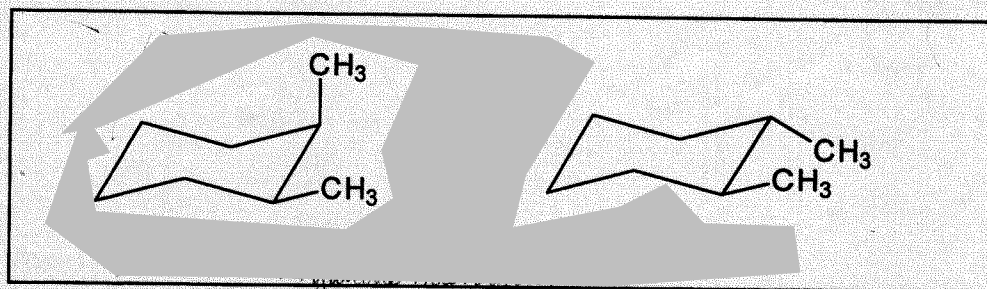
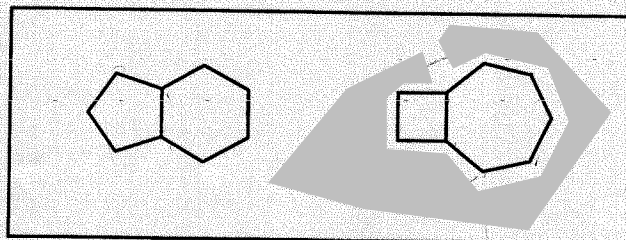
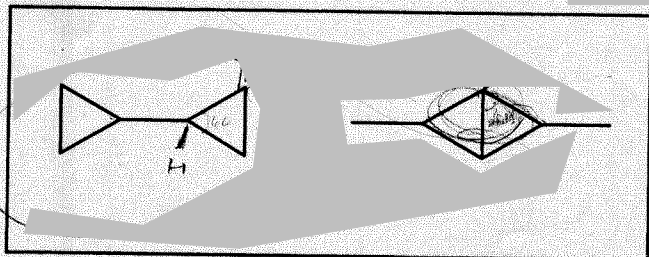
Answer: Weight of oxygen

(b) calculate the equilibrium constant for the reaction of CH_4 with Cl_2 to give CH_3Cl and HCl at 127°C . For this reaction $\Delta S = +0.004 \text{ kcal mole}^{-1} \text{ K}^{-1}$. Show the details of your calculations. Note that other useful data is given on the last page of the exam.

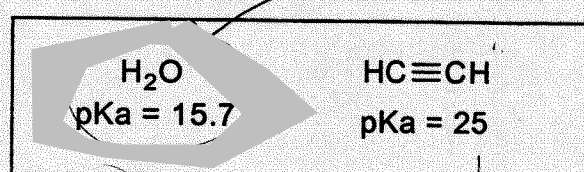
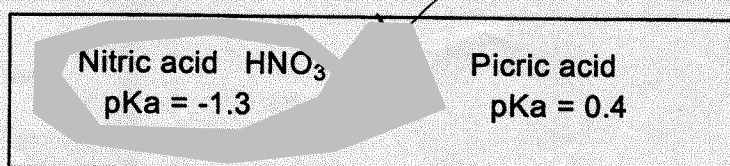
Answer: $K_{\text{eq}} =$

8. (11 points) For multiple choice questions 5a-c, credit will be given for each correct answer, and 1 point will be deducted for each incorrect answer (no credit if no answer is given). For questions 5d and 5e, credit will only be given for correct answers (incorrect answers will not be penalized).

5a. Consider the following pairs of isomeric compounds. Within each pair circle the compound that has the higher heat of combustion.



5b. For each pair of compounds, circle the stronger acid



5c. Circle the strongest base (hint: consider the pKa values given in 5b)



5d. In a competition reaction, equimolar amounts of the four alkanes listed below were allowed to react with a limited amount of Cl_2 at 300°C . Which one of these alkanes would be depleted most from the mixture? (a) Propane, (b) 2-Methylpropane, (c) Pentane, (d) Butane

Answer:



5e. A certain organic compound was found on combustion analysis to contain 84% carbon and 16% hydrogen (C = 12.0 and H = 1.00). A molecular formula for the compound could be:

- (a) $\text{C}_7\text{H}_{16}\text{O}$ (b) C_6H_{12} (c) $\text{C}_{14}\text{H}_{32}$ (d) C_2H_4 (e) $\text{C}_{14}\text{H}_{22}$

Answer:



Note: There are no questions to be answered on this page, it only contains data that may be of use in solving the questions contained in this exam. Not all of the data given is needed.

Value of gas constant: $R = 2.0 \text{ cal deg}^{-1} \text{ mol}^{-1}$

Value of e (base for natural logarithms) $e = 2.718$

Value of absolute zero (kelvin) = -273°C

Bond dissociation energies (in kcal mole⁻¹): Cl-Cl 58; CH₃-H 105; CH₃-Cl 85; H-Cl 103
CH₃-I 57; H-I 71; I-I 36

Values of strain energies:

Each CH₃ - H eclipsing interaction: $1.5 \text{ kcal mol}^{-1}$

Each H - H eclipsing interaction: $1.0 \text{ kcal mol}^{-1}$

Each CH₃ - CH₃ eclipsing interaction: $2.5 \text{ kcal mol}^{-1}$

Each CH₃ - CH₃ butane-gauche interaction: $0.9 \text{ kcal mol}^{-1}$

Each t-Butyl - CH₃ gauche interaction: $2.0 \text{ kcal mol}^{-1}$

Each CH₃ - H 1,3-diaxial interaction: $0.9 \text{ kcal mol}^{-1}$

Each Cl - H 1,3-diaxial interaction: $0.25 \text{ kcal mol}^{-1}$

Each CH₃ - CH₃ 1,3-diaxial interaction: $1.6 \text{ kcal mol}^{-1}$

Each H - CN 1,3-diaxial interaction : $0.1 \text{ kcal mol}^{-1}$

Each H - C(CH₃)₃ 1,3-diaxial interaction: $2.5 \text{ kcal mol}^{-1}$

Partial periodic table of the elements

GROUP	I A	II A	III B	IV B	V B	VI B	VII B	0
VALENCES	+1	+2	+3	-4 +4	-3 +5	-2 +6	-1 +7	0
PERIOD	1							2
1	H 1.008							He 4.003
2	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
3	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3