Chemistry 3A - Spring 1998
Midterm Exam # 1

Professor Jean Fréchet

February 26, 1998

Your full signature_____

Print your full name_____
(Last name, First name, Middle)

Your SID_____

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

_____**111 DeForest,Sarah**
_____**121 Berseth,Polly**
_____**131 Richards,Steven**
_____**141 Yamamoto,Kana**
_____**151 Brennan,Paul**
_____**211 Esker,Todd**
_____**221 Kriesel,Josh**
_____**231 Zylstra,Eric**
_____**361 Liang,Scott**
_____**371 Paisner,Sara**
_____**381 Kim,Esther**
_____**391 Bise,Ryan**

_____**311 DeForest,Sarah**
_____**321 Keet,Corinne**
_____**331 Ponte,Maya**
_____**341 Seymour,Sean**
_____**351 Werkema,Evan**
_____**411 Esker,Todd**
_____**421 Peters,Eric**
_____**431 Freeman,Adam**
_____**511 Liang,Scott**
_____**521 Magliery,Thomas**
_____**531 Kwon,David**
_____**541 Winans,Katherine**
_____**551 Janes,Jeff**

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 80 minutes. No questions will be answered by proctors after the exam begins. Please write legibly; ambiguous or messy answers will receive **no credit**.

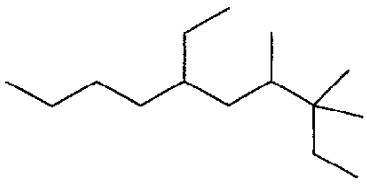
A partial periodic table and data needed for calculations can be found on page 10 of the exam.

Do Not Write in this Box.
1._____(11)
2._____(11)
3._____(12)
4._____(12)
5._____(14)
6._____(11)
7._____(14)
8._____(8)
9._____(7)
Total_____(100)

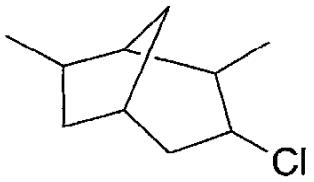
1. (11 points)

1. Name or draw, as appropriate, the following molecules according to IUPAC rules. Do not forget stereochemistry (cis, trans) where appropriate.

a.



b.



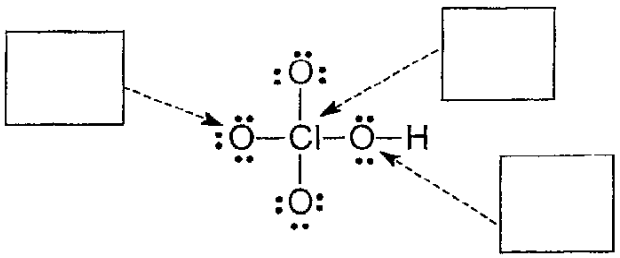
c. Cis-1,3-diethylcyclohexane

(any chair form)

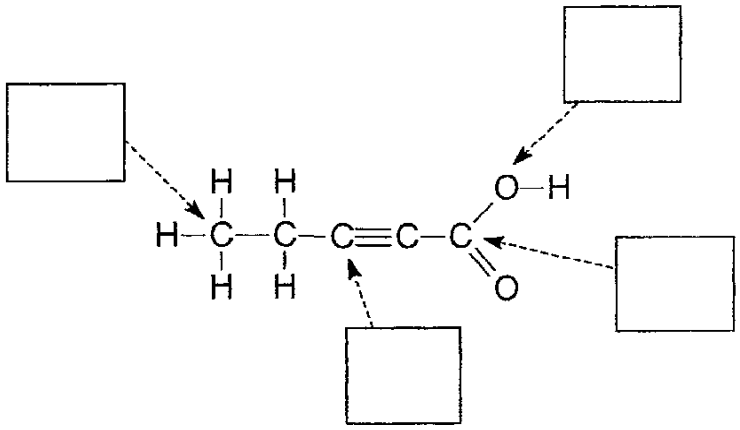
d. Trans-1,2-dichlorocyclobutane

2. (11 points)

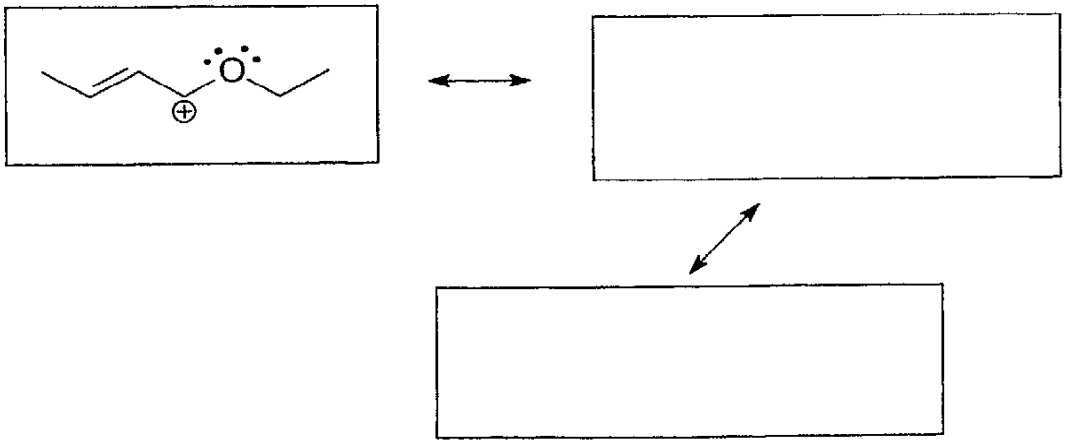
2a. Calculate the formal charge on each of the atoms indicated by an arrow in the structure below. Write the answer in the appropriate box (do not forget the sign!)



2b. What is the hybridization of each atom indicated by an arrow in the structure below. Write the answer in the appropriate box.

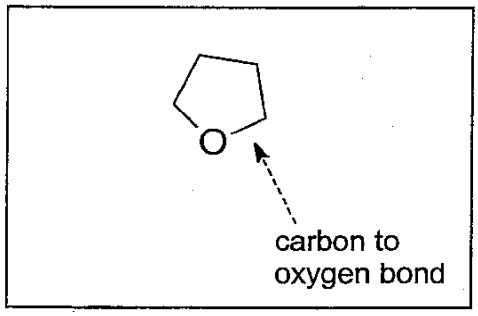


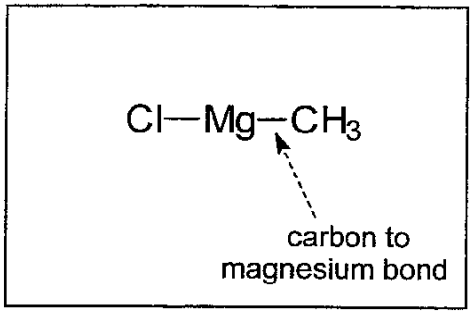
2c. Draw two additional resonance forms for the structure shown below. Your answers should include arrows to show the movement of electrons.



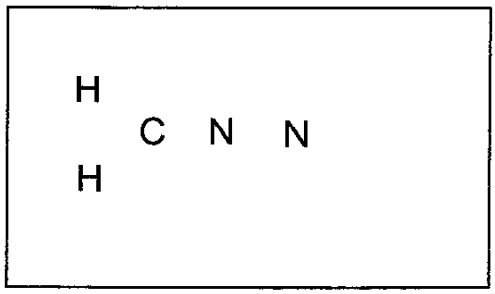
3. (12 points)

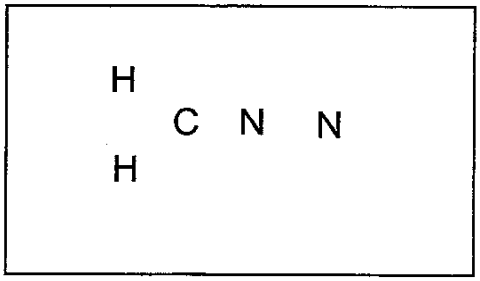
3a. Use the δ^+ and δ^- convention to indicate bond polarization for each bond shown with an arrow





3b. Write a Lewis dot structure for diazomethane H_2CNN, also show a resonance form for this structure and **circle the major resonance contributor.** (Hint: do not forget to show charges if any!)





3c. The ground state electronic configuration of ^{3}Li is ($1s^2$ 2s); write the ground state electronic configuration of aluminum ^{13}Al

4. (12 points)

4. Because fluorine is more electronegative than hydrogen, the molecule HF is polarized towards fluorine and its dipole moment can be shown as indicated below.

(Use this representation to show dipoles in 4b below)

(a) Which of the following molecules, ethene $CH_2=CH_2$ or methanol CH_3OH, would you expect to have the largest dipole moment?

Answer:

(b) Draw clear wedge-dot structures (showing all bonds and all lone pairs) for ethene CH_2CH_2 and methanol CH_3OH and show the dipole direction for each covalent bond, also show the overall dipole direction for each structure.

Ethene

Direction of overall dipole in molecule

Methanol

Direction of overall dipole in molecule

5. (14 points)

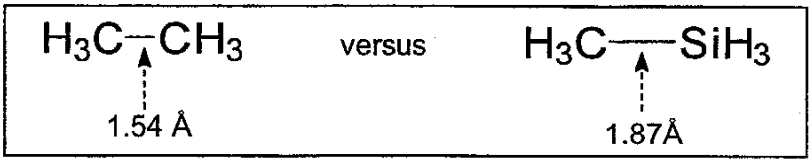
5. Draw the **Newman** projection for the specified conformations of 1-chloropropane $ClCH_2CH_2CH_3$ for rotations about the bonds between C_1 and C_2.

(a) A gauche conformation

(b) The most stable conformation

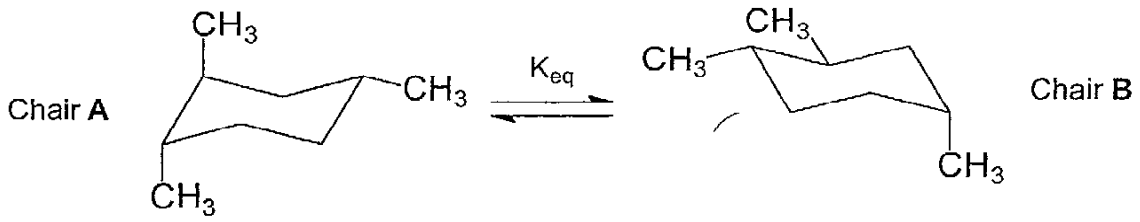
(c) The least stable conformation ⟶

5d. In ethane the barrier to rotation is due to eclipsing strain. What effect on the barrier to rotation would you expect if the carbon-carbon bond of ethane (length C-C = 1.54 Å) was replaced by a carbon-silicon bond (length C-Si = 1.87Å). **Explain your reasoning.**



6. (11 points)

6a. Compare the two conformations of 1,2,4-trimethylcyclohexane below and calculate the energy difference (ΔG^o value) between these two conformers. Explain and show your calculations and **Circle the most stable** conformer (chair A or chair B). See page 10 for data.



Calculations:

Answer: ΔG^o =

6b. Calculate the equilibrium constant K_{eq} and the percentage of chair A at equilibrium at 0°C (see page 10 for data such as the value of the gas constant R).

K_{eq} =

% of chair A =

7. (14 points)

7a. Write a **balanced** equation for the reaction of ethane C_2H_6 with bromine Br_2 in the presence of light to afford 1-bromoethane C_2H_5Br (reaction A).

7b. Write a detailed mechanism showing **each step** in the process of reaction A.

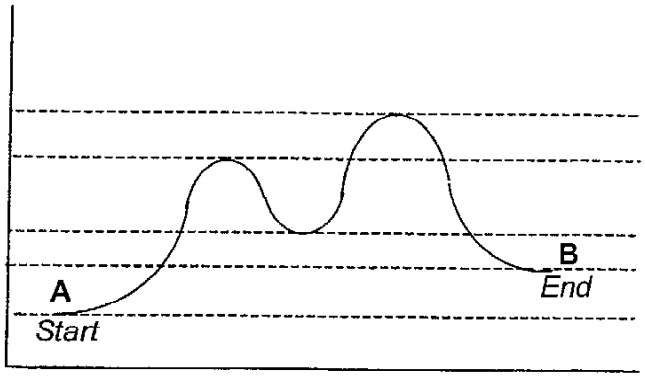
7c. The reaction of ethane C_2H_6 with iodine I_2 in the presence of light is also expected to afford C_2H_5I (reaction B). Using the data given on page 10, calculate the overall value of ΔH° for each reaction (reaction A, then reaction B). **Show your calculations.**

ΔH° for A =

ΔH° for B =

8. (8 points)

8. Consider the qualitative energy diagram below for a hypothetical reaction that affords **B** from **A**.



a. **Label** the axes in the usual fashion (as done in class)

b. **Label** ΔG^{o} on the energy diagram

c. Is the ΔG^{o} for the reaction positive or negative? **Answer:**

d. How many steps are involved in the reaction? **Answer:**

e. **Label** the transition state(s) on the energy diagram (mark each as "**TS**" and use an arrow to locate each precisely on the energy diagram.

f. **Label** the activation energy for the fastest step in the reaction use "$\mathbf{E_{a\text{-}fast}}$" as the label pin-pointing its position on the energy diagram.

9. **(7 points)** Draw a Fisher projection for each of the following compounds and **circle** any that is optically active.

(*R*)-2-chlorobutane

(2*R*,3*S*)-2,3-dibromobutane

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 cal deg^{-1} mol^{-1}

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

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

Values of strain energies:

Each CH_3-H eclipsing interaction: 1.4 kcal mol^{-1}

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

Each CH_3-CH_3 eclipsing interaction: 2.5 kcal mol^{-1}

Each CH_3-CH_3 butane-gauche interaction: 0.9 kcal mol^{-1}

Each CH_3-H 1,3-diaxial interaction: 0.9 kcal mol^{-1}

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

Each CH_3-CH_3 1,3-diaxial interaction: 1.6 kcal mol^{-1}

Bond dissociation energies (in Kcal $mole^{-1}$):

CH_3—H (104)	C_2H_5—H (98)
C_2H_5—I (53)	CH_3—CH_3 (88)
C_2H_5—Br (68)	Br—Br (46)
CH_3—Br (70)	CH_3—I (56)
C_2H_5—C_2H_5 (85)	H—Br (88)
H—I (71)	I—I (36)

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	1 H 1.008							2 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