Chemistry 3A - Fall 1998
Midterm Exam 1

Professor Jean Fréchet

September 23, 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	**Turculet,Laura**	**361**	**Fischer,Fabian**
121	**Klei,Steven**	**371**	**Bennett,Miriam**
131	**Krumper,Jennifer**	**381**	**Fujdala,Kyle**
141	**Downey,Karen**	**411**	**Hodges,Alan**
211	**Eng,Christina**	**421**	**Ahrendt,Kateri**
221	**Shiau,Timothy**	**431**	**Borths,Christopher**
311	**Kita,Ryoko**	**511**	**Saxon,Eliana**
321	**Davis,Anna**	**521**	**Wiener,John**
331	**Yeh,Robert**	**531**	**de Graffenried,Christopher**
341	**Mork,Benjamin**	**541**	**Dosa,Peter**

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.

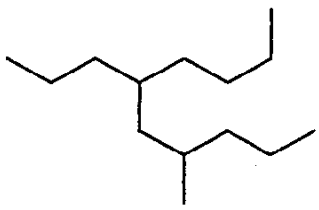
1._____(9)
2._____(9)
3._____(9)
4._____(11)
5._____(9)
6._____(10)
7._____(8)
8._____(10)

Total_____(75)

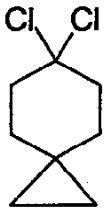
1. (9 points)

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

a.



b.

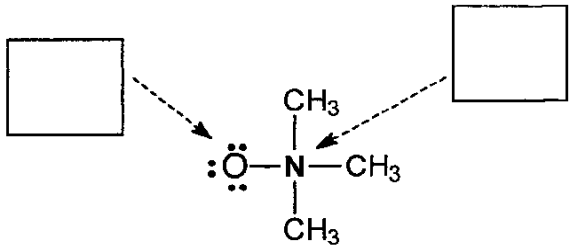


c. cis-1,2-dibromocyclopentane

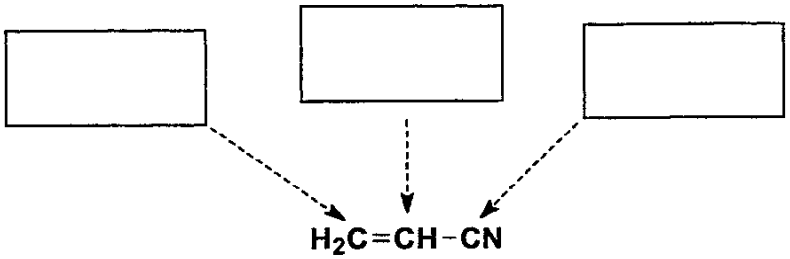
d. 7,7-dimethylbicyclo[2.2.1]heptane

2. (9 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 carbon atom indicated by an arrow in the structure below. Write the answer in the appropriate box.



2c. The dipole moment of methanol CH_3OH is 1.70D.
What does the letter "D" stand for (spell out the name of the unit of dipole moment)

Answer:

2d. Consider the following molecules: HCl, CH_3OH, NH_3, CH_4, $HC{\equiv}CH$ and $H_2C{=}CH_2$

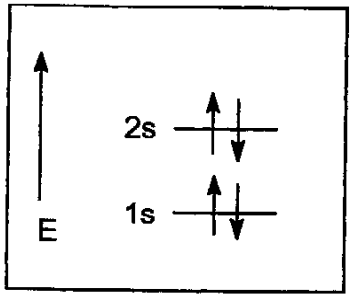
i) Which molecule is the strongest acid? **Answer:**

ii) Which has a pK_a closest to that of water **Answer:**

iii) Which is the most acidic hydrocarbon **Answer:**

3. (9 points)

3a. Using the model given for ^{4}Be below, show the ground state electronic configuration for phosphorus ^{15}P



^{4}Be

^{15}P

3b. Just as Carbon bonds to hydrogen to form methane, phosphorus bonds to hydrogen to form phosphine. Show the Lewis-dot structure of phosphine.

3c. What is the shape of the molecule of phosphine? Explain your answer.

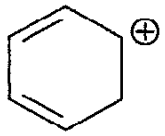
Shape:

Explanation:

4. (11 points)

4a. Show one Lewis-dot representation for the molecule of SO_3 in which S is surrounded by three O atoms and all atoms have an octet. Your answer must clearly show the location of formal charge, if any.

4b. Draw two additional resonance forms for the structure shown below. Your answers should include arrows to show the movement of electrons.



4c. The H–N–H bond angle in ammonia is: (circle one answer only)

60° 90° 109.5° 120° between 109 and 115° between 105 and 110° between 60 and 90°

4d. What is the C-C-C bond angle in the molecule of 1,2-propadiene? Explain briefly using VSEPR

$H_2C{=}C{=}CH_2$ **Answer:** bond angle = [ ]

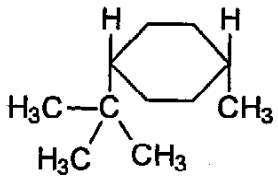
Expanation:

4e. What is the hybridization of the central carbon atom in $H_2C{=}C{=}CH_2$

Answer: hybridization of central C atom: [ ]

5. (9 points)

5a. Draw clear representations of the two possible **chair conformations** for cis-4-t-butyl-1-methylcyclohexane and circle the most stable conformation.



and

5b. Calculate the difference in free energy between these two conformations. Show your detailed calculations and explain clearly the origin of the differences.

Answer:

Explanation and details of calculation:

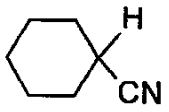
6. (10 points)

6a. Draw a sawhorse projection of the least stable conformation of pentane (draw along the C_2 to C_3 bond of the molecule).

6b. Draw a Newman projection of the most stable conformation of butane (draw along the C_2 to C_3 bond of the molecule)

6c. Draw an energy diagram showing potential energy versus dihedral angle (0 to 180°) for propane $CH_3CH_2CH_3$. Label all axes and use the data on page 10 to scale your drawing indicating the largest energy difference between conformers.

7. (8 Points) (a) Consider the equilibrium between the two chair conformations of cyanocylohexane



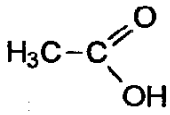
Chair with CN equatorial $\rightleftharpoons$ **Chair with CN axial**

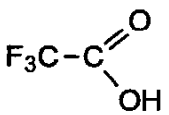
For the process (chair with CN equatorial $\longrightarrow$ chair with CN axial) $\Delta G^0 = +0.2$ kcal mol^{-1}

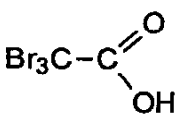
Calculate the percentage of axial cyanocyclohexane at 25°C.
Show equations and a detailed calculation.

Answer: % axial =

(b). Which of the three acids below is strongest? Circle you answer and explain briefly

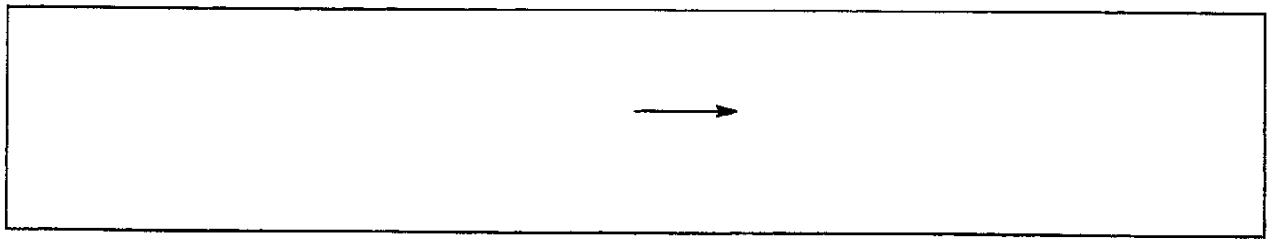






8. (10 Points)

8a. Write a balanced equation for the combustion of cyclohexane in oxygen



8b. What is the relationship between K_a and K_{eq}?

Answer:

8c. Write an equation showing K_{eq} for the following reaction and then calculate the value of K_{eq}. Show your calculations. *(See data on page 10)*

$$HC{\equiv}CH + NH_2^- \overset{K_{eq}}{\rightleftharpoons} HC{\equiv}C^- + NH_3$$

Equation for K_{eq} =

Calculation of K_{eq}

Value of K_{eq} :

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

pK_a values	
HC≡CH	25
HCN	9.3
NH_3	35

Values of strain energies:

Each CH_3 - H eclipsing interaction: 1.5 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 t-Butyl - CH_3 gauche interaction: 2.0 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}

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

Each H - $C(CH_3)_3$ 1,3-diaxial interaction: 2.5 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	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