Chem. 1C Final Exam

June 11, 2002

Name:  

Perm #  

First letter of your last name:  

There are a total of six pages (19 problems) in the exam. All work must be shown on the exam. Show your method of calculation clearly. Correct answers not showing the work will not receive credit. Include the UNITS of all answers.

Notes written on one 8.5 X 11 inch page may be used. All other notes and books are not allowed.

The last page contains information that may be useful as well as a periodic table. You may remove the last page from the exam.

<table>
<thead>
<tr>
<th>Pg 1</th>
<th>(30)</th>
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<tbody>
<tr>
<td>Pg 2</td>
<td>(20)</td>
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<td>Pg 3</td>
<td>(22)</td>
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<td>Pg 4</td>
<td>(40)</td>
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<td>Pg 5</td>
<td>(22)</td>
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<td>Pg 6</td>
<td>(31)</td>
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<td>Total</td>
<td>(160)</td>
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</table>

**NOTE:** The total score is 160, but if you do everything correct and do the extra credit problem your score will be 165/160. Please check your midterm and quiz scores after the final exam on the web. I will keep your exam until the end of Fall quarter. You can come by my office Friday, June 14 or in September to pick up your exam. Hope you have a great summer. ☺
1. Consider the structure for the following compound.

![Chemical structure](image)

a) (4 pts) Write the molecular formula for the compound?

\[ C_{9}H_{15}N_{5} \]

b) (6 pts) Give the approximate values for the bond angles marked a, b and c.

Bond angle a: \(109^\circ\)  
Bond angle b: \(109^\circ\)  
Bond angle c: \(120^\circ\)

c) (6 pts) What is the hybridization on the three nitrogen atoms indicated?

First Nitrogen: \(sp^3\)  
Second Nitrogen: \(sp^2\)  
Third Nitrogen: \(sp^3\)

2. (6 pts) Draw the structure for Cys-Val-Phe in that order.

![Chemical structure](image)

3. (8 pts) Indicate whether or not each of the following quantities affect the vapor pressure of a liquid? Circle the answer.

a) the size of the container holding the liquid-vapor equilibrium \(\boxed{\text{yes}}\) \(\boxed{\text{no}}\)

b) temperature of the liquid \(\boxed{\text{yes}}\) \(\boxed{\text{no}}\)

c) intermolecular forces in the liquid \(\boxed{\text{yes}}\) \(\boxed{\text{no}}\)

d) volume of liquid in the liquid-vapor equilibrium \(\boxed{\text{yes}}\) \(\boxed{\text{no}}\)
4. (20 pts) a) Draw the structure of each of the following compounds. 
b) Draw the optical isomers ONLY IF the 
compound has an optical isomer. c) Identify each chiral carbon by circling it. 
Cross out all structures that are not part of your answer. Points will be taken off for duplicate structures.

a) 2-chloropentane

b) 1-chloropropane

no optical isomers

or tetrahedral

c) 1,3-dichlorobutane

d) 3-bromopentane

no optical isomer
5. Write the balanced equation for the condensation reaction of each of the following.

a) (4 pts) Write the balanced equation for the condensation of cystine with acetic acid (CH₃COOH) to produce an amide.

\[
\text{CH}_3\text{C} - \text{OH} + \text{H}_2\text{N}-\text{C} - \text{C} \text{O} - \text{OH} \rightarrow \text{CH}_3\text{C} - \text{N} - \text{C} - \text{C} \text{O} - \text{OH} + \text{H}_2\text{O}
\]

b) (4 pts) In the presence of a strong dehydration agent such as H₂SO₄, two alcohol molecules react to produce an ether. Write the balanced equation for the condensation of ethanol with 2-methyl-2-propanol to produce an ether.

\[
\text{CH}_3\text{CH}_2\text{OH} + \text{CH}_3\text{C} - \text{CH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{-O} - \text{C} - \text{CH}_3 + \text{H}_2\text{O}
\]

6. (8 pts) There are two possible aldehydes that have the formula, C₄H₈O. Draw the two aldehydes and name them. Draw ONLY two structures. Cross out any structure that is not part of your answer.

Structure:

\[
\text{CH}_3\text{CH}_2\text{C} + \text{H}_2\text{C} - \text{H}
\]

\[
\text{CH}_3\text{C} \text{ H} \text{ C} \text{ H}
\]

Name: butanal 2-methyl propanal

7. (6 pts) For each of the following transformations, state whether the reaction is an oxidation reaction, a reduction reaction or neither. Circle the answer.

a) the conversion of ethyne into ethene

oxidation [ ] reduction [ ] neither [ ]

b) the conversion of ethene into 1,2-chloroethane

oxidation [ ] reduction [ ] neither [ ]

c) the conversion of propanol into propanal

oxidation [ ] reduction [ ] neither [ ]
8. (24 pts) Circle the formula (only one) that best fits each of the following descriptions:

a) polar molecule  
   \[ \text{SO}_3 \quad \text{PCl}_3 \quad \text{CF}_4 \quad \text{CO}_2 \quad \text{BF}_3 \]

b) strongest bond  
   \[ \text{Cl}_2 \quad \text{O}_2 \quad \text{NO} \quad \text{CO} \]

c) most ionic in character  
   \[ \text{CaCl}_2 \quad \text{BaCl}_2 \quad \text{MgCl}_2 \]

d) highest boiling point  
   \[ \text{CH}_4 \quad \text{SO}_2 \quad \text{CO}_2 \]

e) highest boiling point  
   \[ \text{H}_2\text{O} \quad \text{CH}_3\text{OCH}_3 \quad \boxed{\text{C}_{22}\text{H}_{52}} \quad \text{CH}_3\text{CH}_2\text{CH}_3 \]

f) I\(_2\) (s) dissolves in  
   \[ \text{C}_2\text{H}_12 \quad \text{CH}_3\text{OH} \quad \text{H}_2\text{O} \]

g) I\(_2\)(s) dissolves in  
   \[ \text{vinylic} \quad \text{CCl}_4 \quad \text{NH}_3 \quad \text{aq} \]

h) highest boiling point  
   \[ \text{CH}_3\text{SH} \quad \boxed{\text{NH}_3\text{NH}_2} \quad \text{CH}_3\text{OH} \]

i) liquid at room temperature  
   \[ \text{N}_2\text{O} \quad \text{SiO}_2 \quad \text{CH}_3\text{CH}_3 \quad \boxed{\text{CH}_3\text{OH}} \]

j) smallest atomic radius  
   \[ \text{P} \quad \text{Na} \quad \text{Si} \quad \boxed{\text{Cl}} \]

k) highest boiling point  
   \[ \text{Ne} \quad \text{Ar} \quad \boxed{\text{He}} \quad \text{Xe} \]

l) has one \( \pi \)-bond  
   \[ \text{CO} \quad \text{CO}_2 \quad \text{NO} \quad \text{N}_2 \]

9. (6 pts) Indicate the type of crystalline solid formed for each of the following substances.

a) SiO\(_2\)  \text{network} \quad b) \text{CH}_3\text{NH}_2 \quad \text{molecular} \quad c) \text{K} \quad \text{metallic}

10. (10 pts) Pentane (C\(_5\)H\(_{12}\)) and hexane (C\(_6\)H\(_{14}\)) form an ideal solution. The vapor pressure of pure pentane is 530 torr at 25\(^\circ\)C and the vapor pressure of pure hexane is 140 torr at 25\(^\circ\)C. The mole fraction of hexane in a pentane-hexane solution is 0.50. Calculate the mole fraction of pentane in the vapor in equilibrium with this solution at 25\(^\circ\)C.

\[
P_A = \chi_A P_A^0
\]

\[
P_{\text{C}_5\text{H}_{12}} = 0.5 \times (140 \text{ torr}) = 70 \text{ torr}
\]

\[
P_{\text{C}_6\text{H}_{14}} = 0.5 \times (530 \text{ torr}) = 265 \text{ torr}
\]

\[
P_A = P_{\text{C}_5\text{H}_{12}} + P_{\text{C}_6\text{H}_{14}} = 70 + 265 = 335 \text{ torr}
\]

\[
P_v = nRT
\]

\[
\chi = \frac{265}{70 + 265} = 0.79
\]
11. (6 pts) Which of the following complexes has the greatest number of counter ions? No work = No partial credit.

a) hexaaquanickel(II) chloride  
\[
\left[\text{Ni}^{2+} \quad 6 \text{H}_2\text{O}\right] \quad 2\text{Cl}^-
\]

b) tetraaminechloronitrocobalt(III) chloride  
\[
\left[4\text{NH}_3 \quad \text{Cl}^- \quad \text{NO}_2^- \quad \text{Co}^{3+}\right] \quad \text{Cl}^-
\]

c) potassium tetrachloroplatinate(II)  
\[2\text{K}^+ \left[4\text{Cl}^- \quad \text{Pt}^{2+}\right]
\]

d) sodium hexacyanoferrate(III)  
\[3\text{Na}^+ \left[6\text{CN}^- \quad \text{Fe}^{3+}\right]
\]

e) triamminebromoplatinum(II) chloride  
\[
\left[3\text{NH}_3 \quad \text{Cl}^- \quad \text{Pt}^{2+}\right] \quad \text{Cl}^-
\]

12. (4 pts) Which of the following complexes will absorb visible radiation of the shorter wavelength. Circle the answer.

\[
\begin{array}{cccc}
\text{[Co(en)_3]^{3+}} & \text{[Co(NH}_3)_6]^{3+} & \text{[Co(H}_2\text{O})_6]^{3+} & \text{[Co(OH)_6]^{3-}} \\
\end{array}
\]

13. a) (4 pts) Draw the high spin d-orbital diagram for octahedral [Co(H_2O)_6]^{2+} and tetrahedral [CoCl_2(H_2O)_2] complexes.

\[
\begin{array}{c}
\text{Co}^{2+} \\
3 \text{d}^7 \\
\end{array}
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\end{array}
\end{array}
\]

d) (2 pts) Which will absorb light of longer wavelength, [Co(H_2O)_6]^{3+} or [CoCl_2(H_2O)_2]?

\[\text{smaller} \rightarrow \Delta = \frac{hc}{\lambda} \rightarrow \text{longer}\]

14. (6 pts) Draw the geometrical isomers of the complex ion [Fe(H_2O)_2Cl_4]^{2-}.
15. a) (4 pts) Determine the bond order for each of the following species using the MO model.

\[ \text{H}_2 \quad \left( \sigma_{1s} \right)^2 \quad \text{b.o.} = \frac{2-0}{2} = 1 \]

\[ \text{H}_2^+ \quad \left( \sigma_{1s} \right)^2 \left( \sigma_{1s}^+ \right) \quad \text{b.o.} = \frac{2-1}{2} = \frac{1}{2} \]

\[ \text{H}_2^+ \quad \left( \sigma_{1s} \right) \quad \text{b.a.} = 1-0/2 = 1/2 \]

\[ \text{H}_2^+ \quad \left( \sigma_{1s} \right)^2 \left( \sigma_{1s}^+ \right)^2 \quad \text{b.a.} = 2-2/2 = 0 \]

b) (2 pts) Which of the following species is NOT stable according to the MO model. Circle the answer.

\[ \text{H}_2^+ \quad \text{H}_2 \quad \text{H}_2^- \]

16. (6 pts) Phosphorous acid, \( \text{H}_3\text{PO}_3 \) is a diprotic acid. Draw the structure of \( \text{H}_3\text{PO}_3 \) and circle the acidic hydrogens.

\[ O \quad +H \]

\[ \text{or} \quad O = P - O + H \]

17. a) (3 pts) Draw the Lewis structure for allene, \( \text{CH}_2\text{CCH}_2 \).

\[ \text{H} \quad \text{C} = \text{C} = \text{C} \quad \text{H} \]

b) (2 pts) What is the hybridization on the central carbon in allene? \( \text{SP} \)

c) (3 pts) Are all the atoms in \( \text{CH}_2\text{CCH}_2 \) in the same plane? Circle the answer. Yes \( \square \) No \( \square \)

18. (6 pts) Polyethylene is a synthetic polymer that has many uses. 1.40 g of a polyethylene sample is dissolved in enough benzene to make 100 mL of solution, and the osmotic pressure was found to be 1.86 torr at 25°C. What is the molar mass of the polyethylene? Circle the answer. NO WORK = NO CREDIT

a) \( 1.06 \times 10^8 \text{ g/mol} \)

b) \( 1.19 \times 10^4 \text{ g/mol} \)

c) \( 1.06 \times 10^8 \text{ g/mol} \)

d) \( 5720 \text{ g/mol} \)

e) \( 1.40 \times 10^5 \text{ g/mol} \)

\[ \Pi = i \cdot \text{MRT} \quad i = 1 \]

\[ \Pi = \frac{n}{V} \cdot \frac{RT}{1 \text{ atm/760 torr}} \]

\[ n = \frac{\Pi V}{RT} = (1.86 \text{ torr})(1 \text{ atm/760 torr}) \]

\[ (0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}) (298 \text{ K}) \]

\[ n = 1 \times 10^{-5} \text{ mol} \]

\[ 1.40 \frac{g}{1 \times 10^{-5} \text{ mol}} = 1.4 \]

19. (5 pts) For extra credit, you can answer one or both of the following questions. Any reasonable answer will give you full credit. a) For next year, what goals do you have and how will you achieve your goals? b) What advice would you give a new first year student at UCSB to help them succeed? Feel free to use the back of this page if needed.

This is for you ♦ Setting goals and finding a way to achieve goals is very important to help direct and focus your studies. I hope you figure out what excites you so you can enjoy life! ♦
INFORMATION, EQUATIONS AND CONSTANTS

\[ \Delta = \frac{hc}{\lambda} \]
\[ \pi = iMRT \]
\[ \Delta T = i K_b m \]
\[ \Delta T = -i K_f m \]
\[ P = k_T X \]
\[ P_{\text{soln}} = X_{\text{solvent}} P^o_{\text{solvent}} \]
\[ P_A = X_A P^o_A \]
\[ PV = nRT \]

\[
\begin{array}{cccc}
\text{Phenylalanine} & \text{Alanine} & \text{Cysteine} & \text{Valine} \\
\text{H}_2\text{N}-\text{C}=\text{C}^{\cdot} & \text{H}_2\text{N}-\text{C}=\text{C}^{\cdot} & \text{SH} & \text{H}_3\text{C}=\text{C}^{\cdot} \end{array}
\]

\[ I^- < Br^- < Cl^- < F^- < OH^- < H_2O < SCN^- < NH_3 < en < NO_2^- < CO_2, CN^- \]

weak field ligands

strong field ligands

The visible region of the electromagnetic spectrum:

- violet: 400 nm
- blue: 500 nm
- green: 600 nm
- yellow: 600 nm
- orange: 700 nm
- red: 700 nm

The Periodic Table

<table>
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<th>2A</th>
<th>3A</th>
<th>4A</th>
<th>5A</th>
<th>6A</th>
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</table>

Period

- 1A: 1
- 2A: 2
- 3A: 3
- 4A: 4
- 5A: 5
- 6A: 6
- 7A: 7