Chemistry 210 -- EXAM 1 (Fall 2003 - Dr. Robertson)

***** *BEFORE BEGINNING EXAM, PLEASE READ THE FOLLOWING* *****

The exam consists of this cover sheet and fourteen problems, worth the amounts indicated. The extra credit problem shown on the cover sheet is optional. The time limit for this exam is *2 hours* (if more time is needed, you will be moved to the lab).

Please read each of the problems carefully so that you understand the entire problem. No work = no credit.

Key

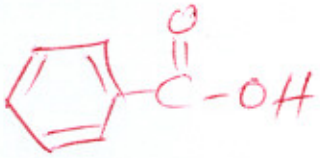
Name: _____

I certify that I did all the work myself and did not cheat in any way.

Signed _____

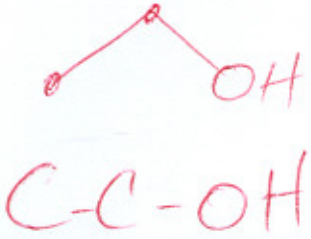
EXTRA CREDIT (4 points): Because the laboratory is an intregral part of this course, what we talk about and do in the lab is often related to what is happening in lecture or vice versa. Therefore, even though some of the chemicals listed below have not been formally talked about in the lecture, we have encountered them in the lab. Show the structures for the following chemicals which have been used in the lab. The first two chemicals are from the lab, and the latter two are chemicals that you should know how to produce their structural formulas.

Benzoic acid



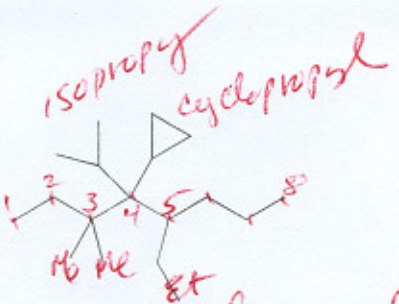
Diethyl ether

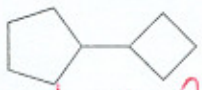
Ethyl alcohol



6-(1-methylpentyl)-5-propyltridecane

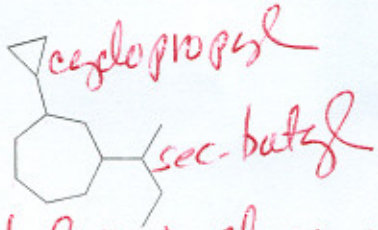
1 (8) Give names for each of the following compounds.

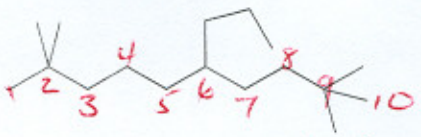




cyclobutylcyclopentane

4-cyclopropyl-5-ethyl-4-isopropyl-3,3-dimethyl-octane





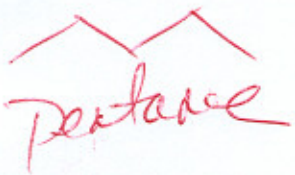
1-sec-butyl-3-cyclopropylcycloheptane

2,2,9,9-tetramethyl-6-propyldecane

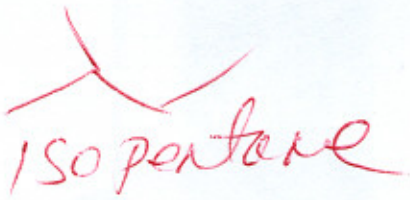
2 (10) Give the names for the alkanes having the number of carbons listed below (6 pts):

2	ethane	8	octane
12	dodecane	3	propane
15	pentadecane	10	decane

Show the structural formulas and give names (IUPAC or common) for the three isomeric alkanes having the molecular formula C_5H_{12}.(4 pts):



pentane



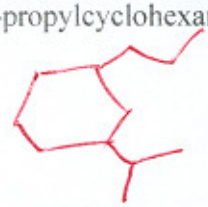
isopentane

neopentane

3 (8) Show structures for the compounds named below:

3-bromo-2-cyclopentyl-4,5,5-triimethylnonane

3-isopropyl-1-propylcyclohexane



5-*sec*-butyl-4-*t*-butyl-6-isobutyldodecane

2-cyclopropyl-4-propyl-octane

4 (16) Give definitions or show a structure which explains the following.

Polycyclic compound

compound w/ more than 1 ring

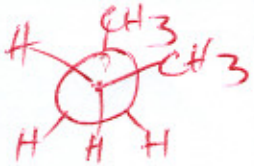
Heterocyclic compound

compound w/ atom other than carbon in ring

Constitutional isomer

same molecular formula but different connectivity

Gauche conformer of butane



Aromatic hydrocarbon

aromatic ring (i.e. benzene — ⬡)

Hybrid orbitals

sp, sp^2, sp^3 etc

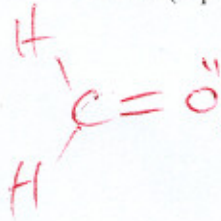
Nucleophile

Lewis base

pK_a value

$-\log[K_a]$

5 (6) (i) Draw the Lewis structure for methanal H_2CO (C is center atom) (3 pts). (ii) What is the formal charge for the carbon in this structure? (1 pt). (iii) What would be the oxidation number for the carbon ~~and~~ atoms (1 pt each)? (iv) What is the orbital hybridization value for the oxygen atom (1 pt) ?

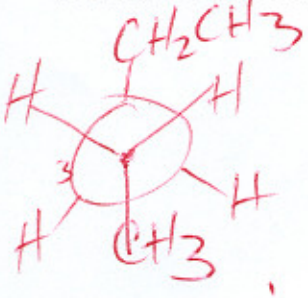
(i) 

(ii) zero (0)

(iii) zero (0)

(iv) sp^2

6 (6) (i) Show correct Newman projection structures for the *anti* and *gauche* conformations of pentane, looking down carbons two and three of this molecule (2 pts each). (ii) Explain why, in one or two sentences, the anti-conformer is most stable. (2 pt).



(ii) farther apart

anti (Gauche is 60° for carbon groups)

7 (4) A new acid that you just discovered has the formula H_5ZO_4. Show the formula for its conjugate base. Then, using the conjugate base you just produced, let it function as an acid, and show the formula for its conjugate base. .

Conjugate acid		*Conjugate base*
H_5ZO_4	→	$H^+ + H_4ZO_4^-$
$H_4ZO_4^-$	→	$H^+ + H_3ZO_4^{2-}$

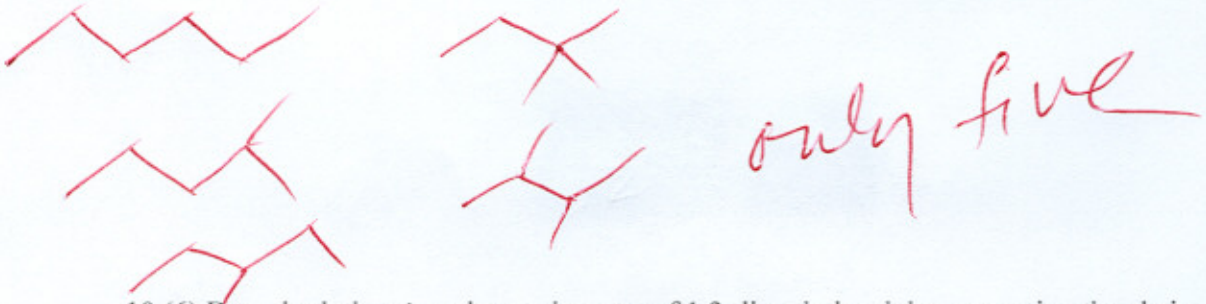
8 (4) HI(aq) has a pK_a of –10.4, and HF(aq) has a pK_a of 3.1. Rank the following acids in order of increasing acidity: HI, HF, HBr, and HCl, using appropriate Periodic Table trends.

Least acidic: HF < HCl < HBr < HI :*Most Acidic*

n-butane
butane

isobutane
2-Methyl-propane

9 (11) (i) Draw structures (7 pts) for as many constitutional isomers having the molecular formula of C_6H_{14} (you need at leat seven to receive full credit for this part). (ii) Give correct IUPAC (2 pts) and common names (2 pts) for the two isomeric butanes.



only five

10 (6) Draw both the *cis* and *trans* isomers of 1,3-dimethylcyclohexane, using the chair conformation for cyclohexane. Be sure to clearly show axial and equatorial orientation in the structure. For both structures, put the methyl group on carbon number 1 in the equatorial position. (4 pts). Which is more stable, and justify your answer (2 pt)?

trans-

cis

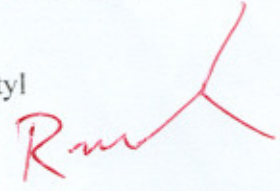
cis more stable — both equatorial

11 (9) Show the structure for each of the following *alkyl groups*, which can be attached to hydrocarbon chains. Show the attachment position going to "R" as the hydrocarbon group to avoid any ambiguity.

Isopropyl

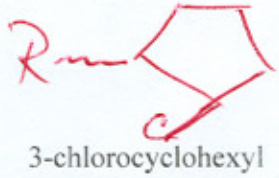
tert-butyl

Isobutyl



sec-butyl

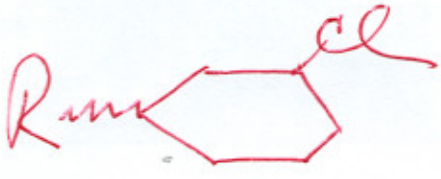
2-methylcyclopentyl



hexyl

2-methylpropyl

3-chlorocyclohexyl



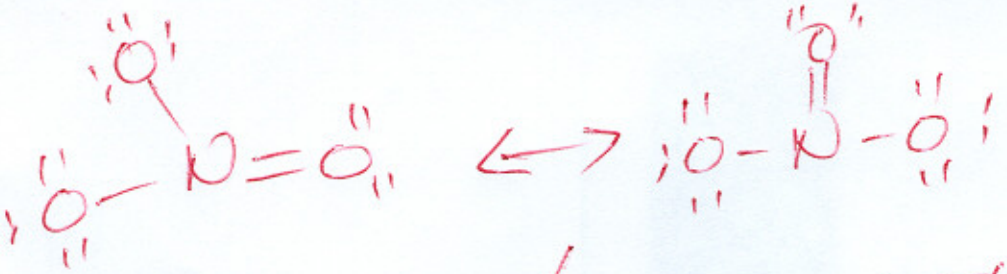
butyl

12 (5) Rank each of the following in order of increasing pKa value (going from most acidic to least acidic, left to right).

H–F 4 H–Cl -3 H–OH 15.7 H–NH_2 36 H–CH_3 60

Smallest: HCl < HF < HOH < NH_3 < CH_4 < Largest

13 (5) (i) Draw the Lewis Structure for the NO_3^- ion (2 pts). (ii) Show one acceptable resonance structure (1 pt). (iii) What is the molecular geometry of this ion (2 pts)?



trigonal planar

14 (6) Give correct acid and base definitions based on the following acid/base descriptions listed below (1 pt each):

Arrhenius definition: Acid: H^+

Base: OH^-

Bronsted-Lowry definition: Acid: proton donor

Base: proton acceptor

Lewis definition: Acid: e^- pair acceptor

Base: e^- pair donor