

Chemistry 230–002 Second Examination

October 23, 2003

Name (please PRINT LEGIBLY) _____
(last) (first)

Student ID # _____

<u>Problem</u>	<u>Score</u>
1. (a-d)	_____ /20
2. (a-f)	_____ /30
3. (a-e)	_____ /25
4. (a-c)	_____ /15
5. (a-b)	_____ /10
Total	_____ /100

Please observe the following.

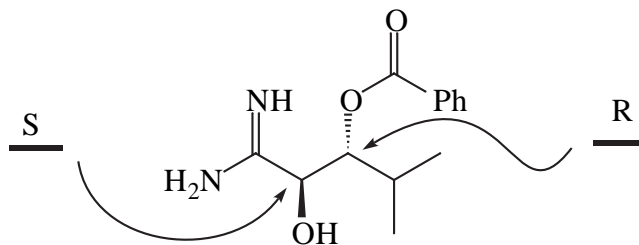
- 1) Write LARGE and LEGIBLY.
- 2) Read each question carefully before answering. Many points are never awarded on every exam because students do not read the instructions.
- 3) Explanations must be clear, coherent, and unambiguous to receive credit.
- 4) For questions with multiple parts, be *consistent*. Your answer to a later part will be graded based on the earlier part being correct, whether or not it actually is. For example, suppose I asked the following questions:
 - (a) What is the hybridization of methane? (5 pts)
 - (b) What is the H–C–H bond angle? (5 pts)

Three students gave the following answers:

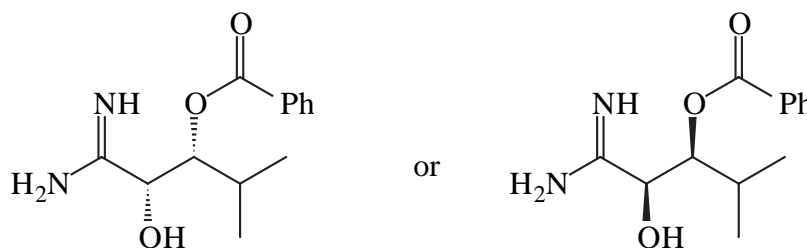
	<u>Student 1</u>	<u>Student 2</u>	<u>Student 3</u>
(a)	sp ²	sp ²	sp ³
(b)	120°	109°	109°
Score:	0 pts + 5 pts	0 pts + 0 pts	5 pts + 5 pts

Student 1 *correctly* answered (b) *given her answer for (a)*. Student 2 *incorrectly* answered (b) *given his answer for (a), even though (b) is formally correct*. Student 3 correctly answered both (a) and (b) and got full credit for the question.

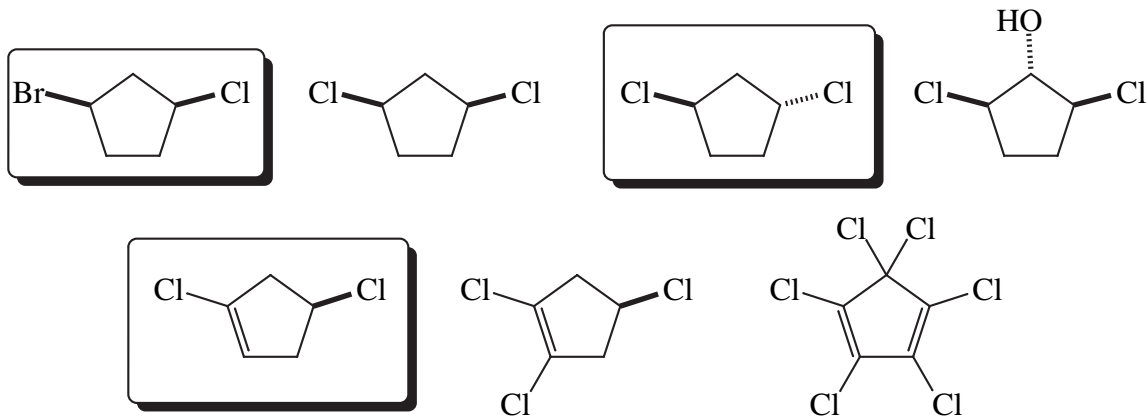
1. (20 pts. total.) (a) (6 pts.) Assign the configurations of the two stereocenters in the compound below.



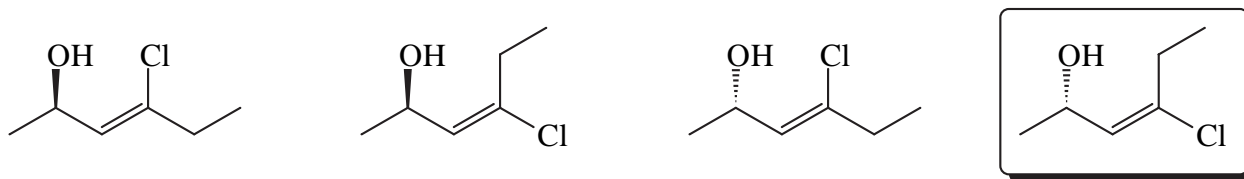
(b) (4 pts.) Draw a configurational diastereomer of the compound above.



(c) (6 pts.) Circle the chiral compounds in the list below.

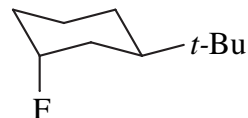
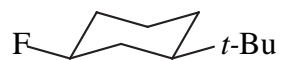


(d) (4 pts.) Circle the compound below whose name is (*S,E*)-4-chloro-3-hexen-2-ol.



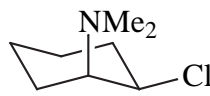
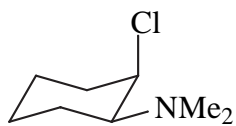
2. (5 pts. each, 30 pts. total.) Describe the relationship of each pair of structures as specifically as possible and in no more than two words.

(a)



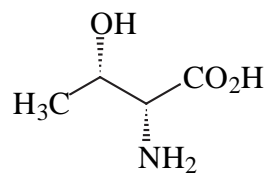
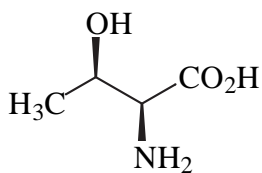
configurational diastereomers

(b)



conformational diastereomers

(c)



configurational enantiomers

(d)



configurational diastereomers

(e)



configurational diastereomers

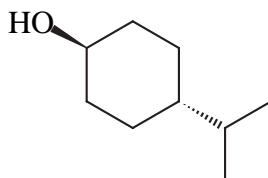
(f)



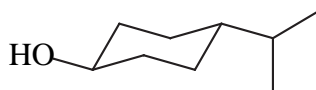
identical (homomers)

3. (25 pts. total.) I hope you practiced drawing your chairs!

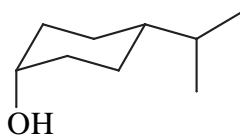
(a) (4 pts.) Draw *trans*-4-isopropylcyclohexanol in planar form (no chair). Be sure to indicate the stereochemistry.



(b) (6 pts.) Now draw *trans*-4-isopropylcyclohexanol in its *lowest energy* conformation.



(c) (5 pts.) Now draw *cis*-4-isopropylcyclohexanol in its *lowest energy* conformation.



(d) (5 pts.) Based on your answers to (b) and (c), is *trans*-4-isopropylcyclohexanol higher in energy, lower in energy, or about the same energy as the *cis* isomer, or is there no way to tell? Explain your answer *briefly* (one sentence).

trans is lower in energy because *trans* has no axial groups and *cis* has one.

(e) (5 pts.) Using the table below, compute the approximate difference in energy between the structures you drew in (b) and (c).

Group	Cost of <i>single</i> 1,3-diaxial interaction with H
OH	0.45 kcal/mol
CH ₃	0.85 kcal/mol
1° alkyl (e.g., Et)	0.90 kcal/mol
2° alkyl (e.g., <i>i</i> -Pr)	1.1 kcal/mol
3° alkyl (e.g., <i>t</i> -Bu)	2.7 kcal/mol

Approximate difference in energy: 2 × 0.45 = 0.9 kcal/mol

4. (5 pts. each, 15 pts. total.) Undergraduate researcher Sally Humdinger acquires a sample of (*R*)-2-chlorobutane of 50% ee. She measures its specific rotation, $[\alpha]$, to be -30° .

(a) What would $[\alpha]$ be for an enantiomerically pure sample of (*S*)-2-chlorobutane? Indicate the sign *and* the magnitude, and explain your reasoning.

If 50% ee rotates 30° , then 100% ee rotates $30^\circ / 0.5 = 60^\circ$. The S isomer would rotate in the opposite direction from Sally's R isomer. Answer: $+60^\circ$.

(b) If Sally converts her (*R*)-2-chlorobutane to (*S*)-2-aminobutane, would you predict that the product would be dextrorotatory, levorotatory, or optically inactive, or would there be no way to tell? Explain your answer.

There's no way to tell, because there is no correlation between stereochemical configuration and optical rotation.

(c) Sally wants to make some enantiomerically pure (*R*)-2-chlorobutane, so she suggests combining butane with Cl_2 to give 2-chlorobutane. She asks you whether her scheme will work. Explain to her whether her scheme will work, and why.

Both butane and Cl_2 are achiral, hence optically inactive, so their reaction will give only optically inactive, racemic 2-chlorobutane. She can't get enantiopure 2-chlorobutane this way.

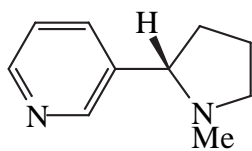
5. (5 pts. each, 10 pts. total.) You travel in a spaceship to the distant planet Htrae, where all molecules are mirror images of the ones here on Earth. NASA has forbidden smoking on its spacecraft, and you're addicted to nicotine, so when you arrive at Htrae you need a smoke, bad. A Htrae life form offers you a drag on the local version of the nicotine delivery device.

(a) Will you feel much better after smoking the Htrae cigarette, much worse, just the same, or is there no way of predicting? Explain your answer briefly. The structure of Earth nicotine is shown below.

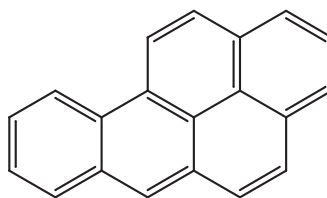
There's no way to tell. Nicotine is chiral, so its mirror image is the enantiomer. Enantiomers may have the same or different biological properties, but there's no way to predict it.

(b) Will the smoke from the Htrae cigarette be more, less, or just as carcinogenic than the smoke from an Earth cigarette, or is there no way of predicting? Explain your answer briefly. The structure of one of the major carcinogens found in Earth cigarette smoke is shown below.

Just as carcinogenic. Benzo[*a*]pyrene is achiral, so its mirror image is identical to itself. The Htrae carcinogen will have the same biological properties as the Earthly stuff.



Nicotine



Benzo[*a*]pyrene, a typical cigarette carcinogen