CH301H – Principles of Chemistry I: Honors
Fall 2011, Unique 51040

Exam 4
17 November 2011

Name: Key

You may use your textbook and a calculator for arithmetic. Assume an ideal gas unless instructed otherwise.

Honor Code:

"The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community."

I certify that the work on this exam is entirely my own.

Signature _______________________________ Date

1. (15 points) True / False. Determine whether each of the following statements are true, false, or if there is no way to know (NWTK) with the given information.

a) True False NWTK It takes lower energy to rotate an alkene around the C-C bond than an alkyne.

b) True False NWTK All real gasses behave ideally in the limit of infinitely high pressure.

c) True False NWTK One mole of an ideal gas at constant pressure will have a volume at 60°C that is twice that of the same gas at 30°C. need T in kelvins!

d) True False NWTK When comparing any two atoms or molecules, the one at higher temperature will have a higher root-mean-squared speed. depends on FW

e) True False NWTK When an atom is hybridized to make a polyatomic molecule, the number of hybrid orbitals is always equal to the number of original atomic orbitals minus one.

2. (15 points) Each of the following statements is a characteristic of either a bonding, antibonding, or nonbonding molecular orbital. For each statement, fill in the blank with the appropriate orbital.

anti Energy is always higher than the corresponding atomic orbitals

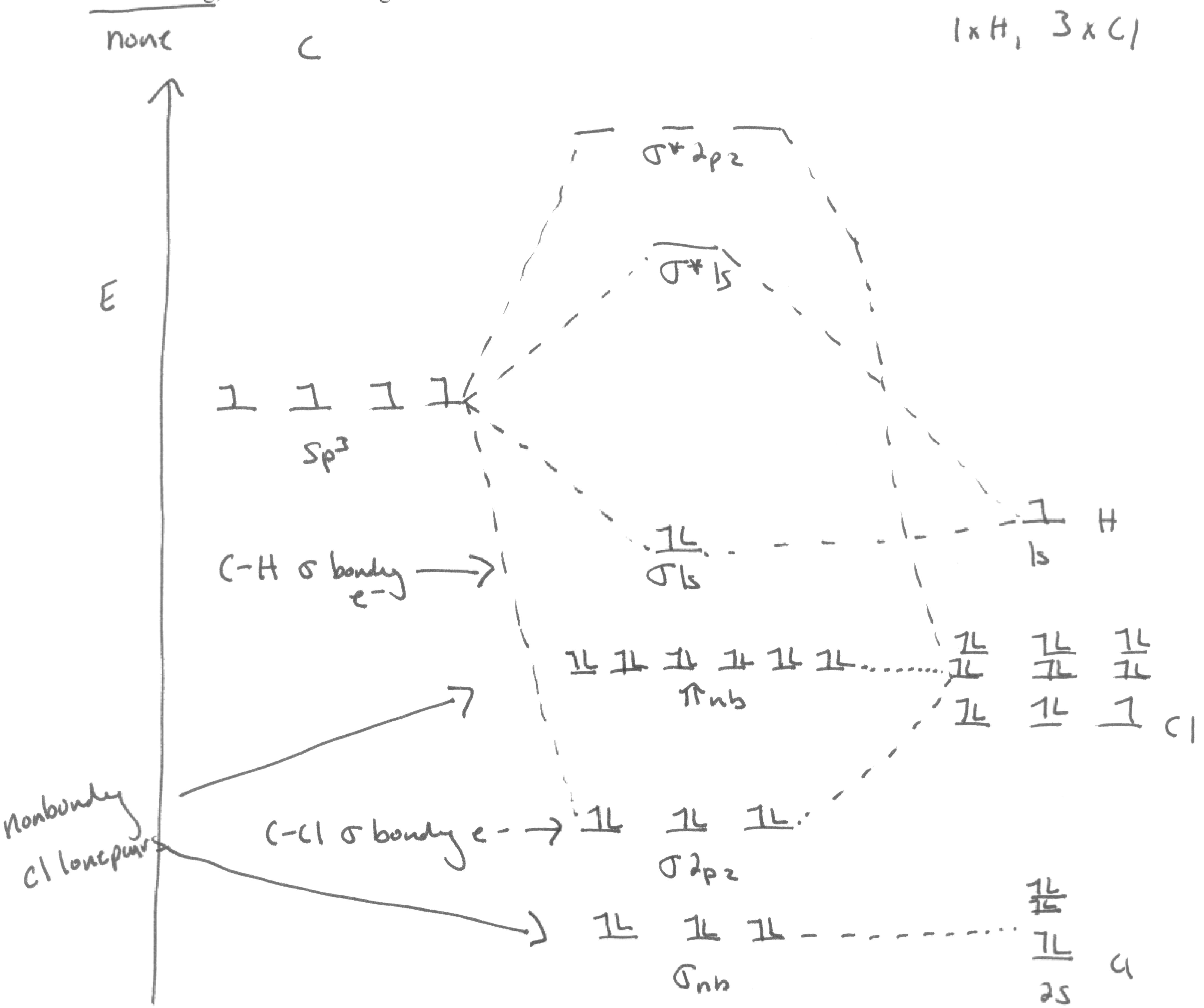
bonding Energy has a minimum at a particular distance between the two nuclei

nb Energy does not depend on the distance between the two nuclei

antibonding Electron density is greater on the atom with the smallest electronegativity

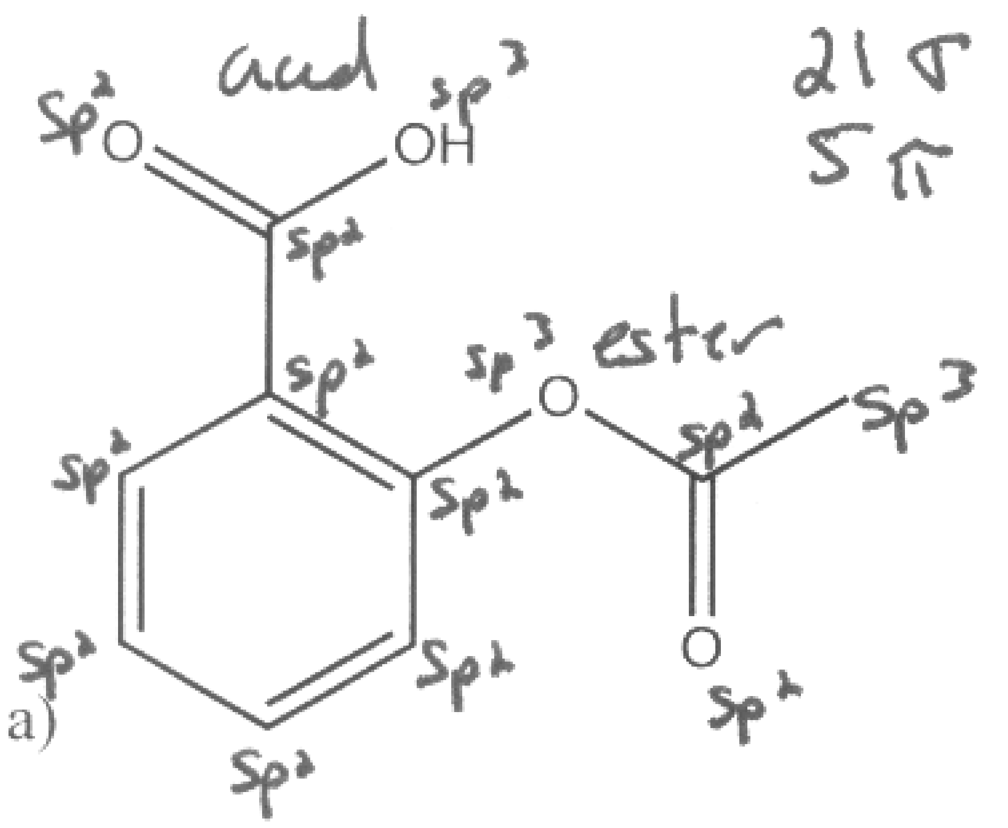
anti Orbital with a wavefunction has a node between the two nuclei

3. (30 points) Draw the molecular orbital diagram for chloroform ($CHCl_3$). Identify all bonding, antibonding, and nonbonding electrons.

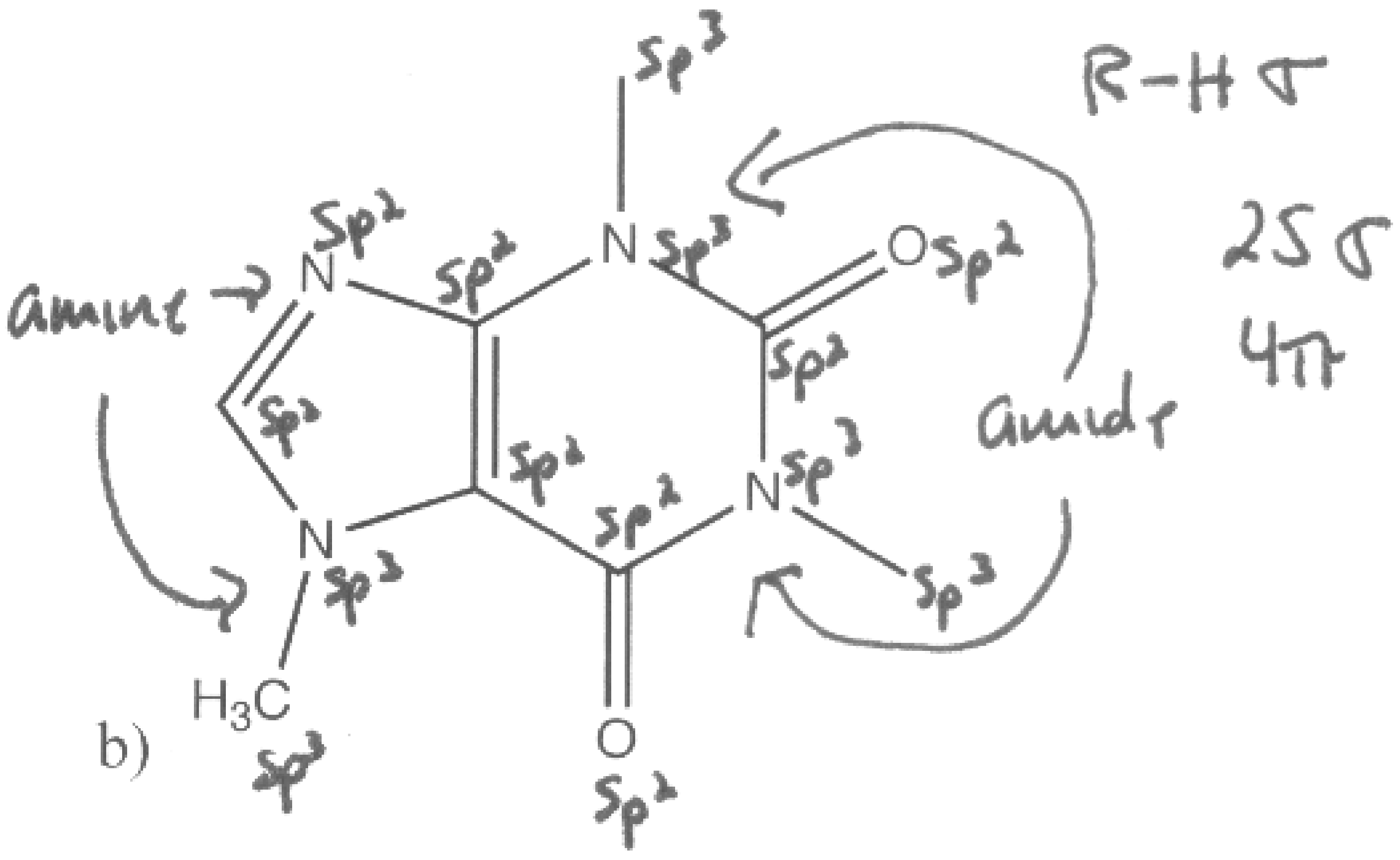


or could hybridize the Cl to make 4 sp³ orbitals per Cl. The distribution of e⁻ in bonding + non bonding orbitals will be the same

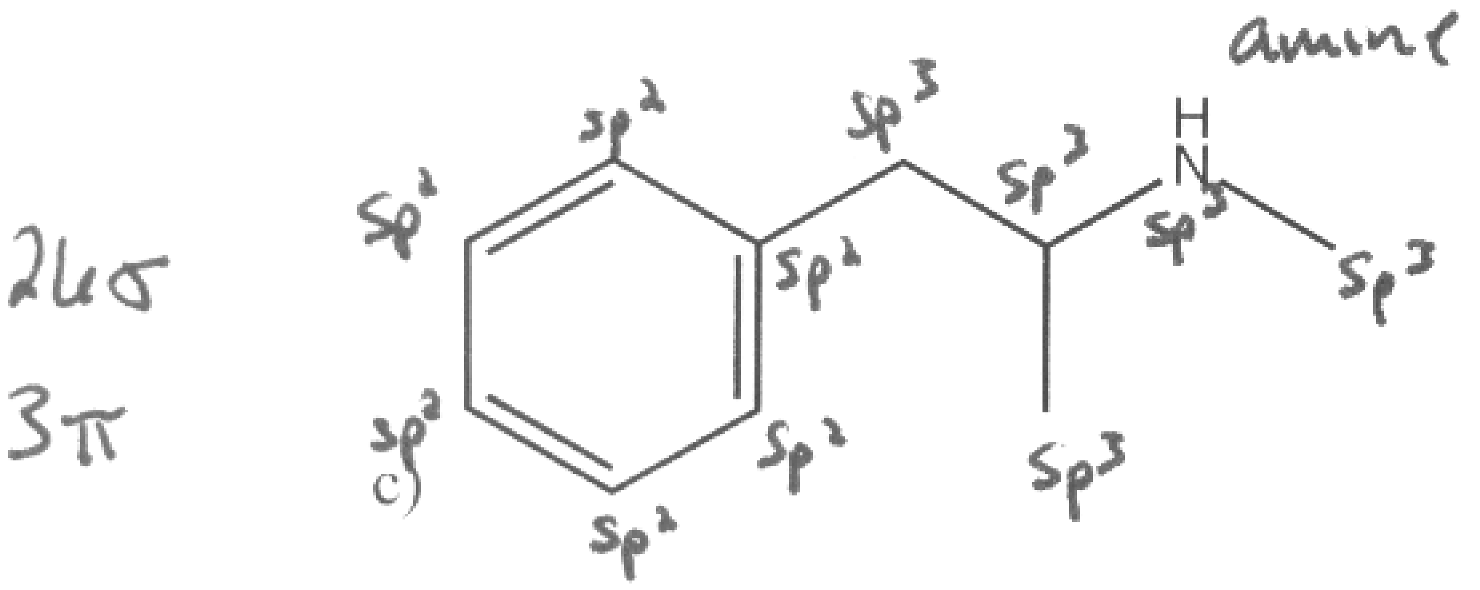
4. (20 points) For each of the following molecules, i) identify all functional groups, ii) identify hybridization at each C, O, and N atom, and iii) identify the total number of σ and π bonds. remember R-H σ



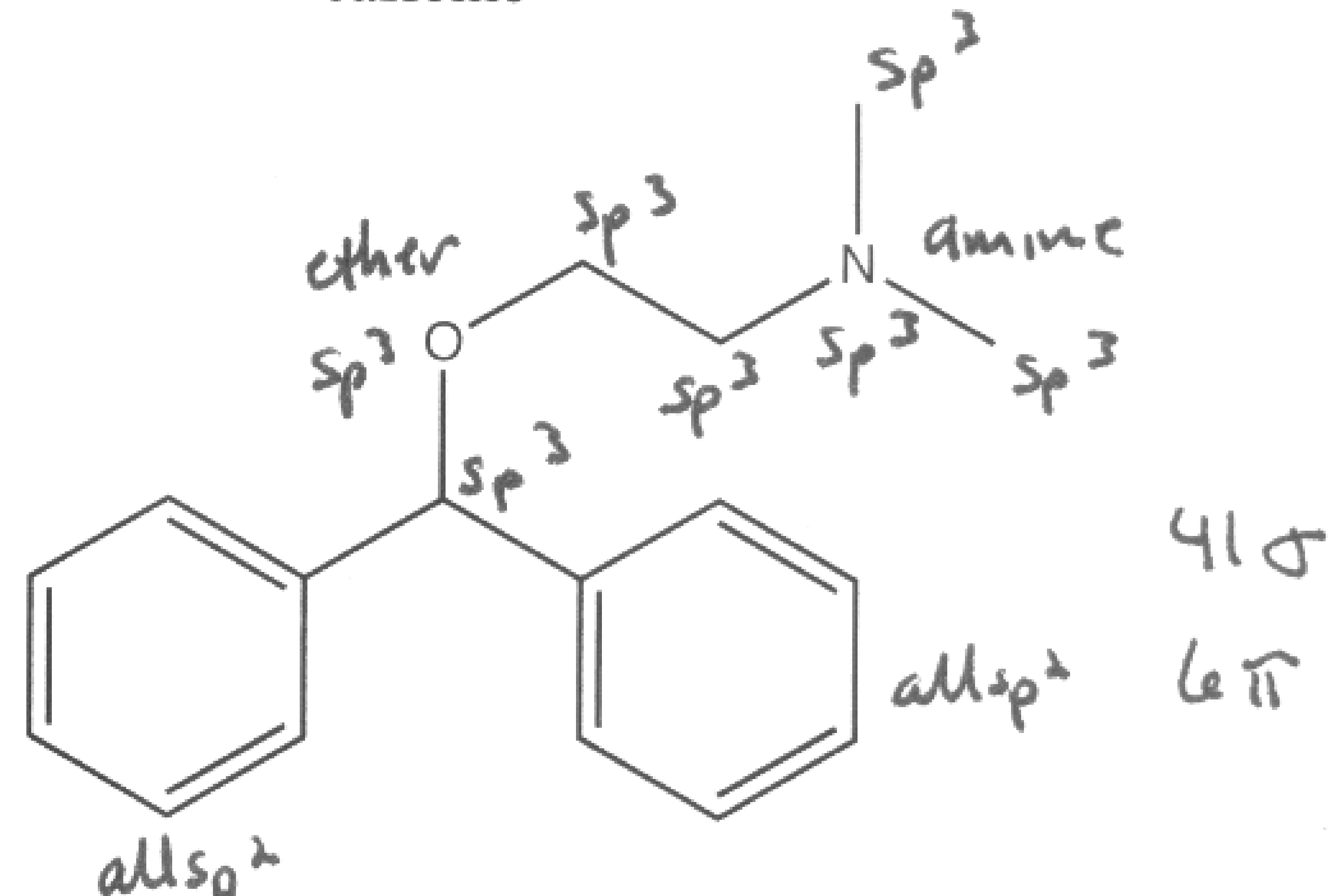
a) acetylsalicylic acid (aspirin)



b) caffeine



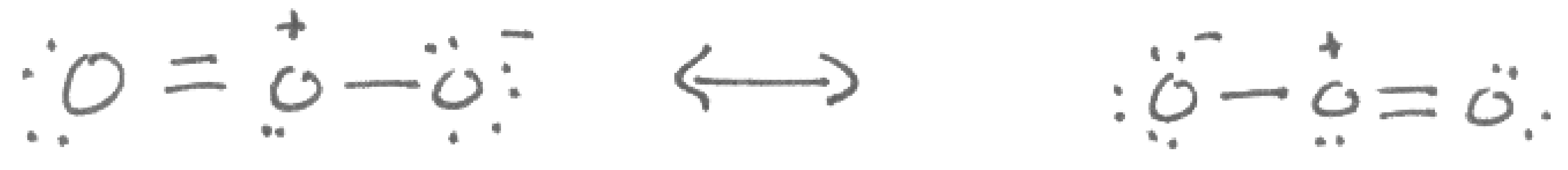
c) methamphetamine



d) diphenhydramine (ingredient in Benadryl)

5. (10 points) Ozone (O_3) is an important molecule in atomospheric chemistry.

a) Draw the Lewis dot structure of O_3, being sure to account for all lone pairs.

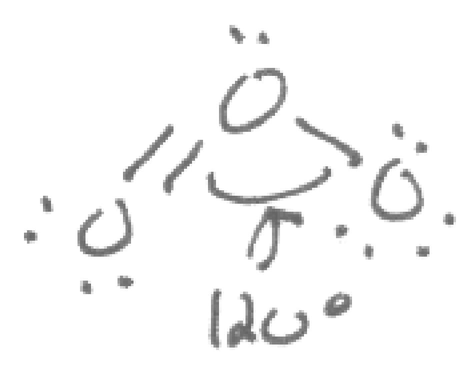


b) Determine the hybridization of each O atom.

Because the molecule is a combination of both resonance structures, each O must be sp^2 hybridized

c) Determine the geometry of the central O atom. What is the angle between the two O-O bonds?

$sp^2 \Rightarrow$ trigonal planar $\Rightarrow 120°$



6. (10 points) The escape velocity necessary for objects to leave the gravitational field of the earth is 11.2 km s^{-1}. It is thought that early earth was considerably hotter than it is now, and that a primitive atmosphere was composed of nonreactive H_2 and N_2 molecules. Determine the ratio of the escape velocity to root-mean-squared speed for each of these molecules at 2000 K. Does your result help explain the low abundance of H_2 in the current atmosphere? Why or why not?

$$C_{rms} = \left(\frac{3RT}{FW}\right)^{1/2}$$

$T = 2000\,k$

$R = 8.31\ J/k\,mol$

$FW(H_2) = 0.002\ kg/mol$

$FW(N_2) = 0.028\ kg/mol$

$V_{esc} = 11.2 \times 10^3\ m/s$

$$N_2:\quad C_{rms} = \left(\frac{3(8.31\ J/k\,mol)(2000\,k)}{0.028\ kg/mol}\right)^{1/2} = 1.3 \times 10^3\ m/s$$

$$\frac{V_{esc}}{C_{rms}(N_2)} = 8.4$$

$$H_2:\quad C_{rms} = \left(\frac{3(8.31\ J/k\,mol)(2000\,k)}{0.002\ kg/mol}\right)^{1/2} = 5.0 \times 10^3\ m/s$$

$$\frac{V_{esc}}{C_{rms}(H_2)} = 2.2$$

So it is much more likely that a portion of H_2 molecules will have sufficient speed to escape the atmosphere, and thus would help explain why there is none left.