

Chem 2210-01 Organic Chemistry

Exam 1

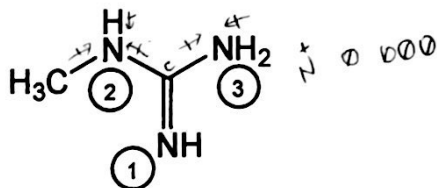
October 16, 2020

1. The following compound names are all incorrect or incomplete, but they represent real structures. Draw each structure and name it correctly. (8%)

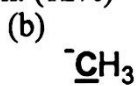
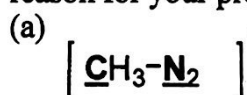
(a) 3-*tert*-butyl-hexane

(b) 2,4-diethylpentane

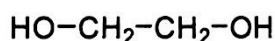
2. The following compound contains three nitrogen atoms. Rank these three nitrogen atoms in an order of decreasing basicity. Give your reason for the arrangement. (5%)



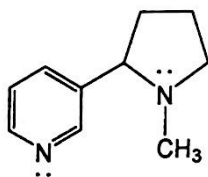
3. What is the hybridization of labeled atom in each of the following molecules. Give a brief reason for your prediction. (12%)



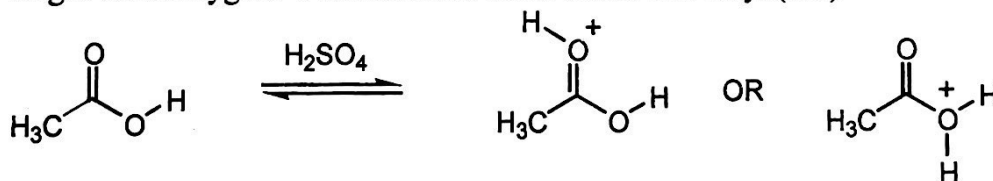
4. Use Newman projection to draw *totally eclipsed*, *eclipsed*, *gauche*, and *anti* conformations for 1,2-ethandiol(ethylene glycol). Which conformer is the most stable one? Give a reason for your prediction. (12%)



5. In which orbitals are the lone pairs in nicotine?(4%)



6. Acetic acid can be protonated by H_2SO_4 either on its double-bond oxygen or on its single-bond oxygen. Which form is more stable and why?(6%)



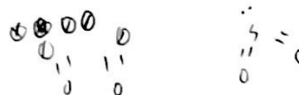
7. Heats of combustion for some alkanes are shown in the following table. What is the strain energy of cyclopropane? (3%)

alkanes	cyclopropane	cyclobutane	cyclohexane	hexane	octane
Heat of combustion (kcal/mol)	499.8	655.9	944.5	995.0	1309.8 163.9

8. A compound has the concentration of 1000 times greater in its acidic form than in its basic form at pH = 6. what is K_a of this compound? (3%)

$$pK_a = pH + \log \frac{[HA]}{[A^-]} \text{ acid}$$

9. Sulfur dioxide has a dipole moment of 1.60 D. Carbon dioxide has a dipole moment of zero, even though C-O bonds are more polar than S-O bonds. Explain this apparent contradiction. (5%)

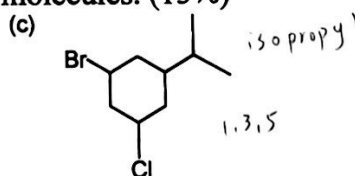
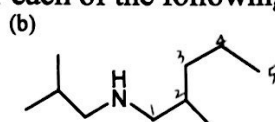
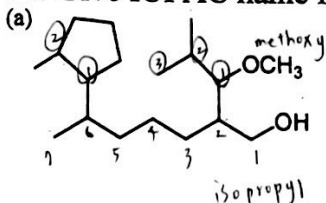


10. List the following compounds in an order of decreasing boiling point and give a brief explanation. (4%)



London
dipole
Li Be B C N O F
1 1.5 2 2.5 3 3.5
Na Mg Al Si P S
0.9 1.2 1.5 1.8 2.1 2.4

11. Give IUPAC name for each of the following molecules. (15%)

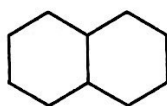


meth eth prop but pent
hex hept oct non dec

12. The energy difference in two chair conformations of *cis*-1,3-dimethylcyclohexane has been measured as about 5.4 kcal/mol. Which is the more stable conformer? (2%) How much of this energy difference is due to the torsional energy of gauche relationships? (Note: One gauche interaction is 0.87 kcal/mol) (4%) And how much energy is due to the additional steric strain of the 1,3-diaxial interaction? (2%)



13. Draw the most stable conformation for each of *cis*- and *trans*-decalin. Use what you know about the conformational energies of substituted cyclohexanes predict which is the more stable isomer. How much energy difference between these two molecules? Give detail information. (10%)



decalin

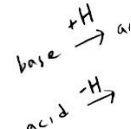


trans

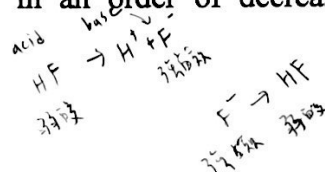
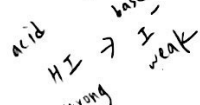


14. Calculate the energy difference between the two chair conformations of *trans*-1,4-dimethylcyclohexane. (5%)

(Note: One gauche interaction is 0.87 kcal/mol)



15. Rank the halide ions (F^- , Cl^- , Br^- , I^-) in an order of decreasing basicity. Give a brief explanation. (6%)



國立清華大學試卷

記分		分	
1	6	2	2
3	4	4	12
5	4	6	3
7	0	8	3
9	5	10	4
11	10	12	8
13	10	14	5
15	6	16	
17		18	
19		20	
總分		82	

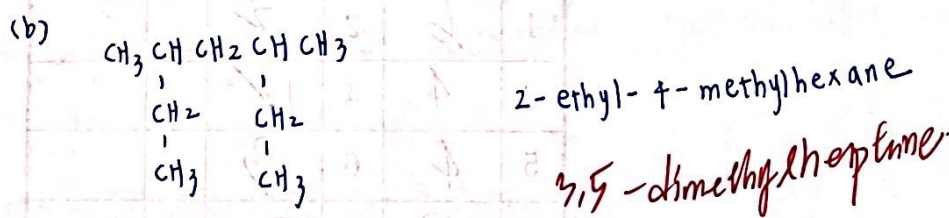
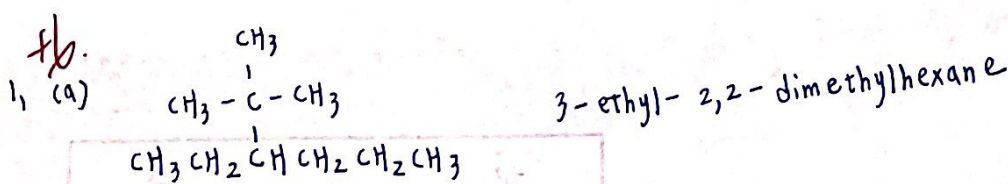
所系 化學系

科目 有機

學號 108023025

姓名 張小萱

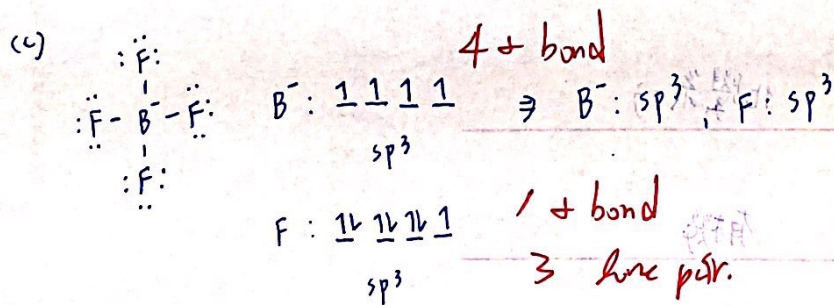
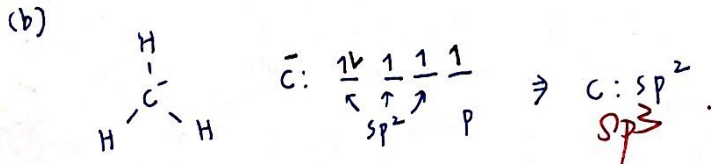
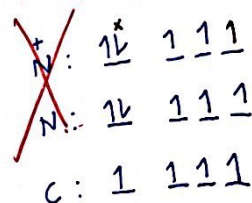
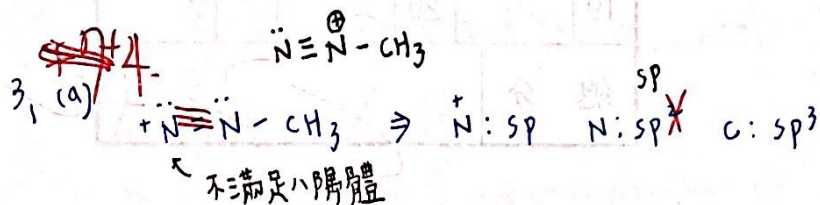
日期 109, 10, 16



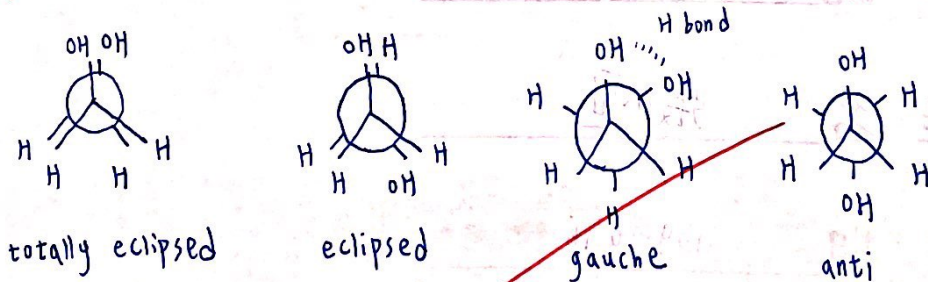
2, $\text{f} \checkmark$ basicity ① > ② > ③ #

N^\oplus sp^2 hybridization, more %s than sp^3 , bonding electrons closer to nucleus, most stable (weak)
 For conjugated acid, $\left[\text{H} - \text{N}^\oplus - \text{CH}_3 \right]$

N^\oplus bonds with more H (RNH_3 $\text{pK}_a \sim 10$), strongest conjugated acid
 stronger the conjugated acid, weaker the basic inductive effect.

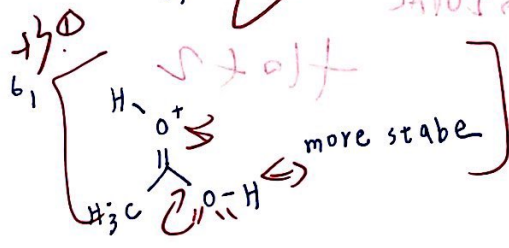
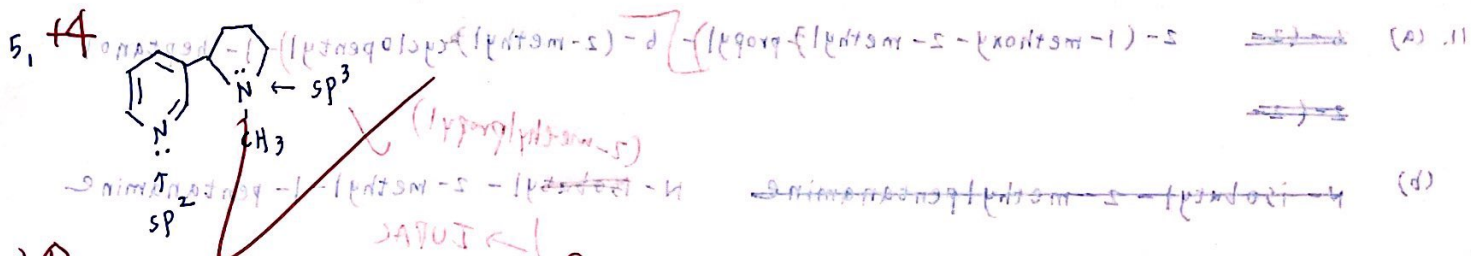


4, $\text{f} \checkmark$



gauche most stable #

stagger is more stable than eclipse, there is H bond in gauche conformation while



XO^+ hybridization sp^2 (will be sp^3 in another form), higher %s, bonding electrons closer to nucleus, more stable

7, ⁴ Heat of combustion of propane (X) $\frac{6-3}{8-6} = \frac{995-X}{1309.8-995}$ $X = 522.8 \text{ kcal/mol}$

\Rightarrow strain energy: $= 522.8 - 499.8 = 23 \text{ kcal/mol}$ #

$\frac{1309.8-995.0}{2} = 157.4 \text{ (CH}_2\text{)}$

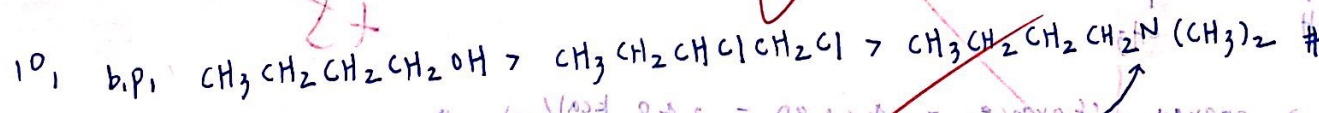
$157.4 \times 3 = 472.2$ $499.8 - 472.2 = 27.6$

8, $pK_a = 6 + \log \frac{1000}{1}$, $pK_a = 9$, $K_a = 10^{-9} \text{ (M)}$ #

9, the bond angle in CO_2 is 180° (no lone pairs on C) $\leftarrow \text{O}=\text{C}=\text{O} \rightarrow$ $\text{抵消} = 0$

while bond angle in SO_2 is smaller than 180° (one lone pairs on S)

so it has dipole moment



can form hydrogen bond (strongest non-covalent interaction)

larger dipole (2Cl vs. 1N), & doesn't have London force also bigger

11. (a) ~~2-(1-methoxy-2-methylpropyl)-6-(2-methylcyclopentyl)-1-heptanol~~

~~2-(1-methoxy-2-methylpropyl)-6-(2-methylcyclopentyl)-1-heptanol~~

(b) ~~N-isobutyl-2-methylpentanamine~~

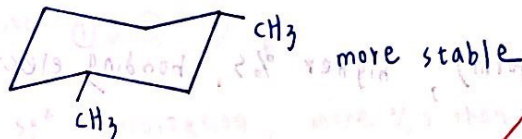
(2-methylpropyl) ✓
N-isobutyl-2-methyl-1-pentanamine

(c) 1-bromo-3-chloro-5-isopropylcyclohexane
(1-methylethyl) ✓

→ IUPAC

+10+2

12. (a)



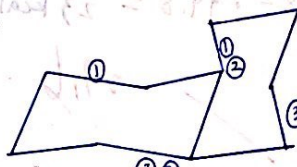
(b) 4 gauches in another form: $4 \times 0.87 = 3.48$ kcal/mol

(c) $5.4 - 3.48 = 1.92$ kcal/mol

13.



trans-decalin

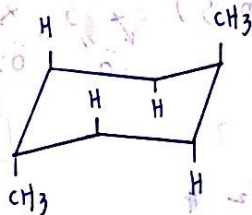


cis-decalin

trans-decalin more stable (both substitutions are on equatorial)

3 gauches in cis-decalin (marked in ① ② ③) ⇒ energy difference = $3 \times 0.87 = 2.61$ kcal/mol

14.



no energy differ

4 CH₃-H ⇒ energy difference = $4 \times 0.87 = 3.48$ kcal/mol

15. conjugated acid: HF, HCl, HBr, HI

bigger the size, lower the electron density (more stable) ⇒ HI weakest conjugated acid

strong basic has weak conjugated acid ⇒ basicity $I^- > Br^- > Cl^- > F^-$

pKa HF > HCl > HBr > HI (size ↑ ⇒ electron density ↓)
strongest acid, weakest conjugated base

⇒ basicity $F^- > Cl^- > Br^- > I^-$