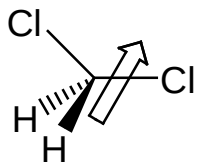
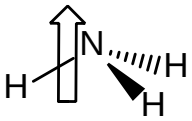
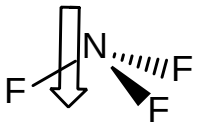
1. For the following compounds, answer the questions.

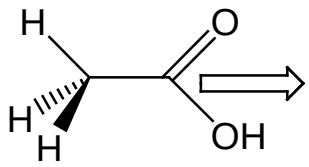
(A) CH_2Cl_2 (B) NH_3 (C) NF_3 (D) CH_3COOH (E) CH_2=CHCl

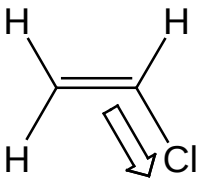
(a) [5 x 2 points] Draw the perspective formulas of each compound showing 3-D shape of the molecule and indicate the direction of the dipole moment of the molecule. Use heavy (solid) and dashed (hatched) wedges if necessary.

(A) 

(B) 

(C) 

(D) 

(E) 

[1 pt for structure and 1 pt for direction]

(b) [3 points] The dipole moment of C (0.24D) is much smaller than that of B (1.47D). Explain.

In NH_3, the dipole moment is toward the more electronegative nitrogen, and toward the lone pair. In NF_3 the dipoles of the N–F bonds are directed toward the more electronegative fluorine, and away from the lone pair, so the resultant dipole moment is much smaller and away from the lone pair.

(c) [3 points] Which of B or C is a weaker base? Explain.

Fluorine has an electron withdrawing effect that reduces the availability of the pair of electrons on nitrogen. Thus the basicity of :NF3 is less than that of :NH3.

2. [3 x 3 points] **Tell whether the statement is correct or false, and explain your answer.**

(a) Hund's rule dictates that, when degenerate orbitals are available, electrons first occupy them in pairs with opposite spins.

False. [1 pt]
Hund's rule says that electrons occupy degenerate orbitals singly with the same spin. [2 pts]

(b) While bonding molecular orbitals do not have nodal plane, anti-bonding molecular orbitals have.

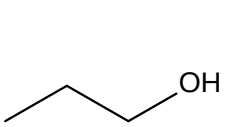
False. [1 pt]
Bonding MOs can have nodal planes. [2 pts]
The given statement should be corrected to: 'While bonding MOs do not create new nodal planes, while anti-bonding MOs do.'

(c) Hybridization states of carbon in methyl cation and methyl anion are different.

Correct. [1 pt]
Methyl cation has sp^2 carbon, while methyl anion has sp^3 carbon. [2 pts]

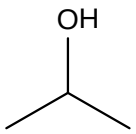
3. For C_3H_8O answer the following questions.

(a) [9 x 1 point] Draw the three (3) structural isomers, and name them by using both common and systematic (IUPAC) nomenclatures.



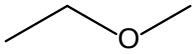
propyl alcohol

propan-1-ol



isopropyl alcohol

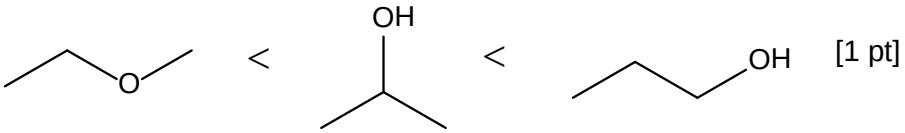
propan-2-ol



methyl ethyl ether
(ethyl methyl ether)

methoxyethane

(b) [3 points] Arrange the isomers in the increasing order of boiling point. Explain your answer.

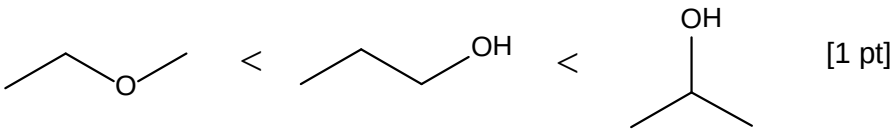


[1 pt]

H-bonding stronger than dipole-dipole interaction
[1 pt]

Linear molecule has larger contact area
[1 pt]

(c) [3 points] Arrange the isomers in the increasing order of solubility to water. Explain your answer.



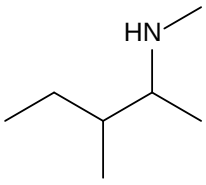
[1 pt]

H-bonding to water
[1 pt]

Branched nonpolar part has smaller contact area with water
[1 pt]

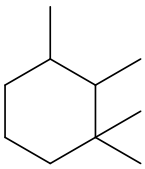
4. [2 x 3 points] **Give the systematic name of the following compounds.**

(a)



N,3-dimethylpentan-2-amine

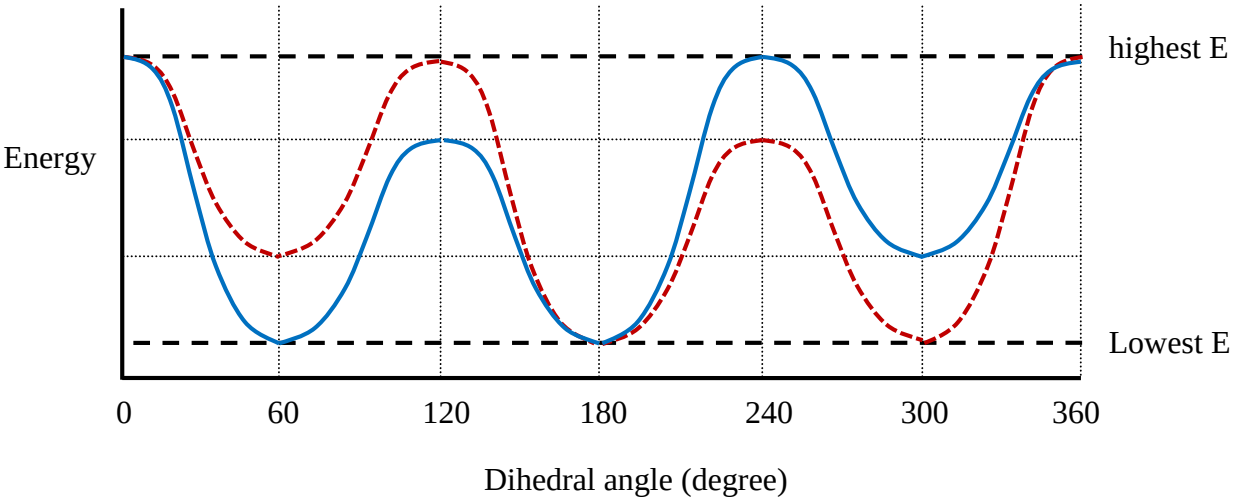
(b)



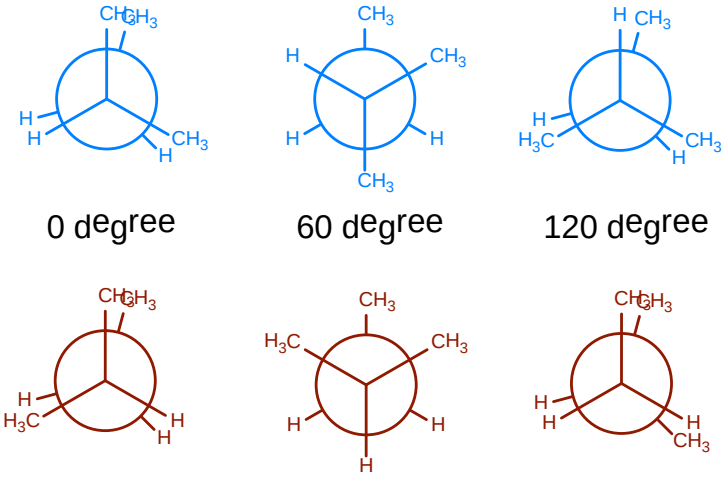
1,1,2,3-tetramethylcyclohexane

5. For 2-methylbutane answer the following questions.

(a) [6 points] Construct the energy – dihedral angle plot for the conformations about the C2-C3 bond. Start (zero degree) with the highest energy conformation, and rotate the front carbon (C2) clockwise.

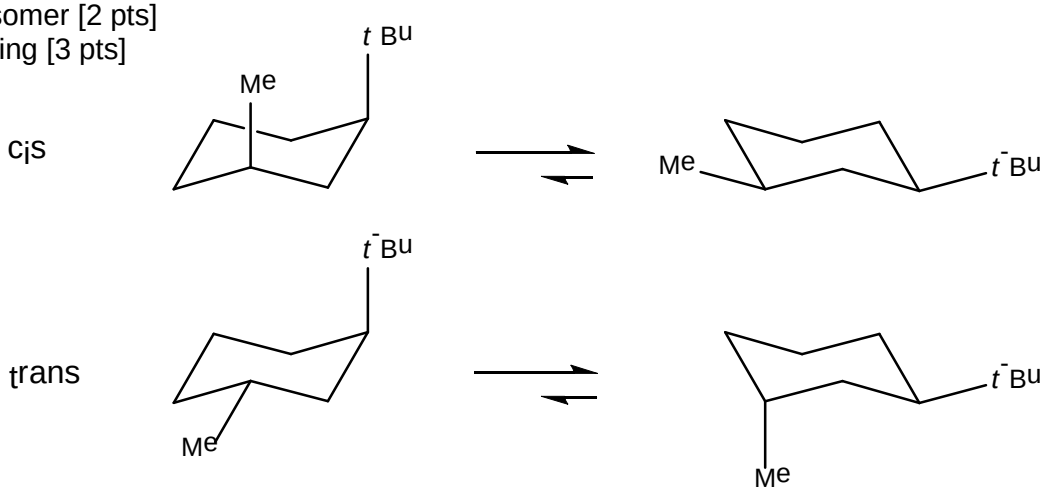


(b) [3 x 2 points] Draw the Newman projections of the conformations at 0, 60, and 120 degree.



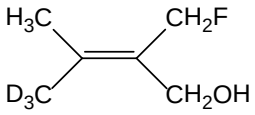
6. [6 points] **For 1-*tert*-butyl-3-methylcyclohexane, is *cis*- or *trans*-isomer more stable? Explain your answer.**

cis-isomer [2 pts]
drawing [3 pts]

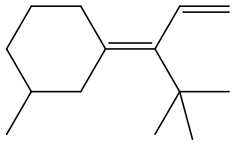


The more stable conformer of *cis*-isomer is more stable, since both methyl and *t*-butyl group is in equatorial position. [1 pt]

7. [2 x 3 points] **Assign the following configuration as *Z* or *E*.**

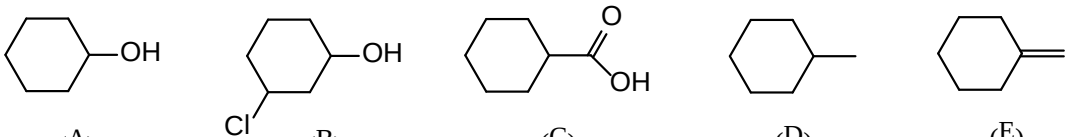
(a) 

E

(b) 

Z

8. [6 points] **Arrange the following compounds in the order of increasing acidity, and explain your answer.**

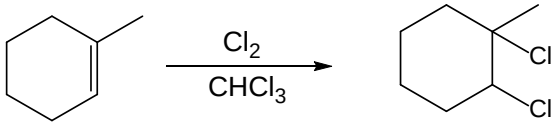


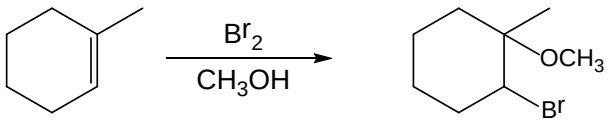
(A) (B) (C) (D) (E)

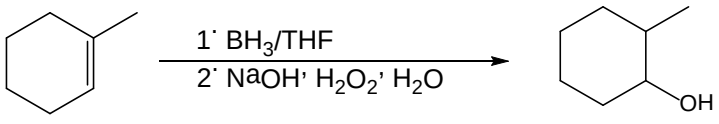
D < E < A < B < C [2 pts]

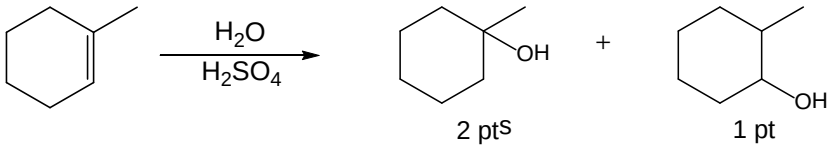
Alcohols and carboxylic acid [A, B, and C] are more acidic than hydrocarbons [D and E], since their hydrogens are bonded to more electronegative atom O, which stabilize conjugate base better than C. [1 pt]
C is most acidic, since its conjugate base is resonance-stabilized (with delocalized electrons). [1 pt]
B is more acidic than A, since Cl withdraws electrons to stabilize conjugate base. [1 pt]
E is more acidic than D, since sp2 carbon is more electronegative and better stabilizes conjugate base, carbanion. [1 pt]

9. [4 x 3 points] **Show the product(s) of the following reactions.**

(a) 

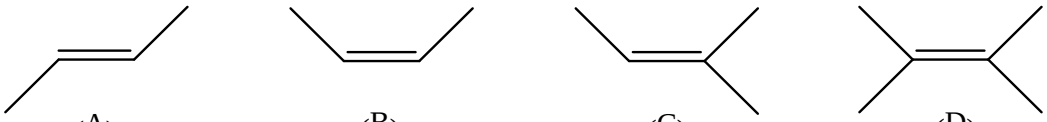
(b) 

(c) 

(d) 

2 pts 1 pt

10. [4 x 3 points] **The following alkenes are subjected to acid-catalyzed hydration. Answer the questions.**



(A) (B) (C) (D)

(a) Arrange A, B, C, and D in the increasing order of stability. Briefly explain your answer.

B < A < C < D [1 pt]

More substituted alkene is more stable due to hyperconjugation. [1 pt]
For disubstituted alkene, trans-isomer A is more stable than cis-isomer B due to steric hindrance. [1 pt]

(b) The reaction of B is faster than that of A. Explain why.
(c) The reaction of C is faster than that of A. Explain why.
(d) The reaction of D is faster than that of C. Explain why.

These questions are exactly the same to Problem 53 of Chapter 4. Look up the answers in Study Guide.