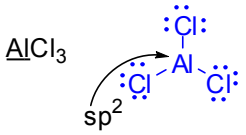
# CHM 1321

[redacted] - **Answers**

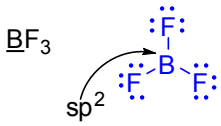
1) Draw Lewis structures for the following molecules. Identify the hybridization oft the underlined atoms.

a.



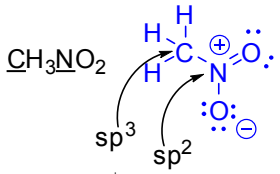

The "p" orbital is empty

b.

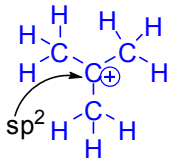



The "p" orbital is empty

c.

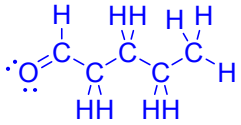



d. $(CH_3)_3\underline{C}^+$

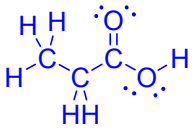



The "p" orbital is empty

e. Pentanal

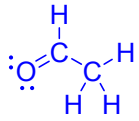


f. Propanoic acid

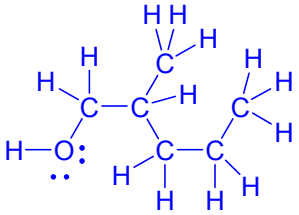


g. Formaldehyde

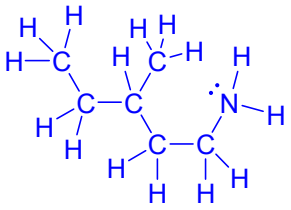
h. Acetaldehyde



i. 2-methylpentan-1-ol

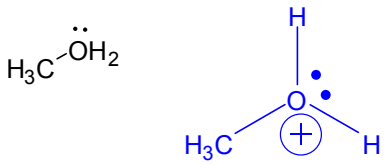


j. 3-methylpentan-1-amine



2) Each structure below is missing a charge—assign formal charges to show which atom bears the charge.

a.

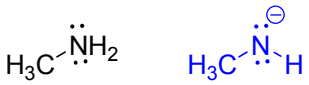


FC (oxygen) = 6-3-2 = +1

b.

FC (nitrogen) = 5-4-0 = +1

c.



FC (nitrogen) = 5-2-4 = -1

d.

FC (oxygen) = 6-3-2 = +1

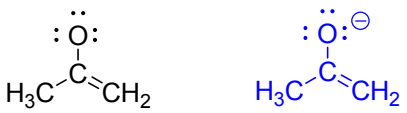
e.

FC (carbon) = 4-3-2 = -1

f.

FC (carbon) = 4-3-2 = -1

g.

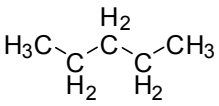


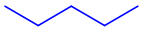
FC (oxygen) = 6-1-6 = -1

3)

a. Convert each of the following molecules to a line structure
b. Name each compound

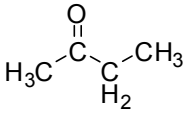
i.

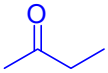




pentane

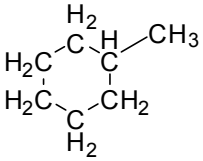
ii.

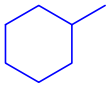




2-butanone

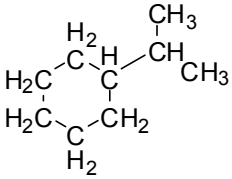
iii.

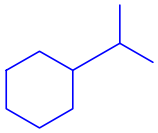




1-methylcyclohexane

iv.

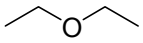




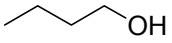
isopropylcyclohexane
OR
1-(1-methylethyl)cyclohexane

NOTE: Don't forget to include the "cyclo" when naming cyclic molecules!

4) Diethyl ether and 1-butanol have similar solubilities in water, but their boiling points are very different. Explain why these compounds have similar solubility properties but different boiling points.



solubility 8.4 mL in 100 mL $H_2O$
bp 35 °C

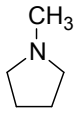


solubility 8.9 mL in 100 mL $H_2O$
bp 118 °C

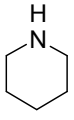
Each molecule has about the same amount of Van der Waals interactions, and the Van der Waals surfaces are relatively large. Each compound has a dipole, lone pairs on oxygen and is able to hydrogen bond with water. Therefore each compound has similar solubility in water.
The hydrogen bonds in butanol are stronger that the dipole interactions in diethyl ether. Butanol has a higher boiling point because of the stronger hydrogen bonds. The intermolecular forces holding the butanol molecules together are stronger than those holding the diethyl ether molecules together.

5) Explain the difference in boiling point for the following pairs of compounds:

a)



and

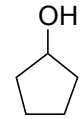


bp 81 °C

bp 106 °C

Each molecule has about the same Van der Waals ability. N-methyl-pyrrolidine (on the left) is capable of dipole-dipole interactions. Piperidine (on the right) has a dipole and can also hydrogen bond with itself (lone pair of electrons and hydrogen on the nitrogen atom). Therefore Piperidine has the higher boiling point.
**Note**: The nitrogen of N-methyl-pyrrolidine has a lone pair and can hydrogen bond with water (water donates the hydrogen and is called a hydrogen bond donor). N-methyl-pyrrolidine donates the lone pair

and is called a hydrogen bond acceptor. N-methyl-pyrrolidine cannot hydrogen bond with itself because there are no hydrogens on polar heteroatoms (N) in this structure.

b)  and 

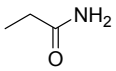
bp 141 °C bp 88 °C

Each molecule has about the same Van der Waals ability. Both molecules have dipoles. Cyclopentanol (on the left) is capable of hydrogen bonding with itself. Tetrahydropyran (on the right) is only capable of dipole-dipole interactions. Therefore cyclopentanol has the higher boiling point since hydrogen bonds are stronger than dipole interactions.

6) Which of the following compounds can form hydrogen bonds? Which can form hydrogen bonds with water?

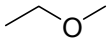
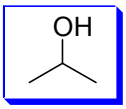
a)  b)  c) 

d)  e)  f) 

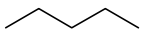
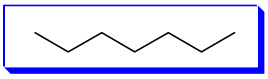
g) 

Compounds (a) and (g) can form hydrogen bonds between their own molecules. Each of these has hydrogens capable of hydrogen bonding (H's on nitrogen) and heteroatoms with lone pairs (N in structure (a); N and especially O in structure (g).
Compounds (a) and (g) can of course form H bonds with water. Compounds (b), (d) and (f) can form weaker hydrogen bonds with water. They have no hydrogens available, but do have lone pairs that can form hydrogen bonds with water.

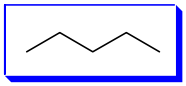
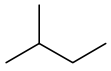
7) Predict which of the following pairs of compounds will have the higher boiling point and explain your prediction.

a)  or 

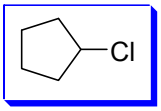
Both have dipoles, however the second structure is capable of hydrogen bonding with itself (H and lone pairs on oxygen). These molecules held together by hydrogen boonds

b)  or 

Most Van der Waals forces because of larger molecules

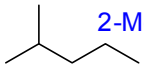
c)  or 

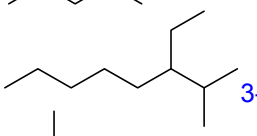
Most Van der Waals forces due to least amount of branching (largest contact area)

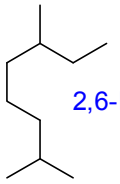
d)  or 

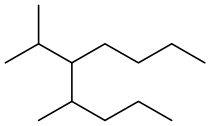
Dipole-Dipole interactions, cyclohexane has Van der Waals forces only. Dipole-Dipole interactions are stronger than Van der Waals forces.

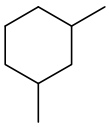
8) Provide names for the following compounds

a)  2-Methylpentane

b)  3-Ethyl-2-methyloctane

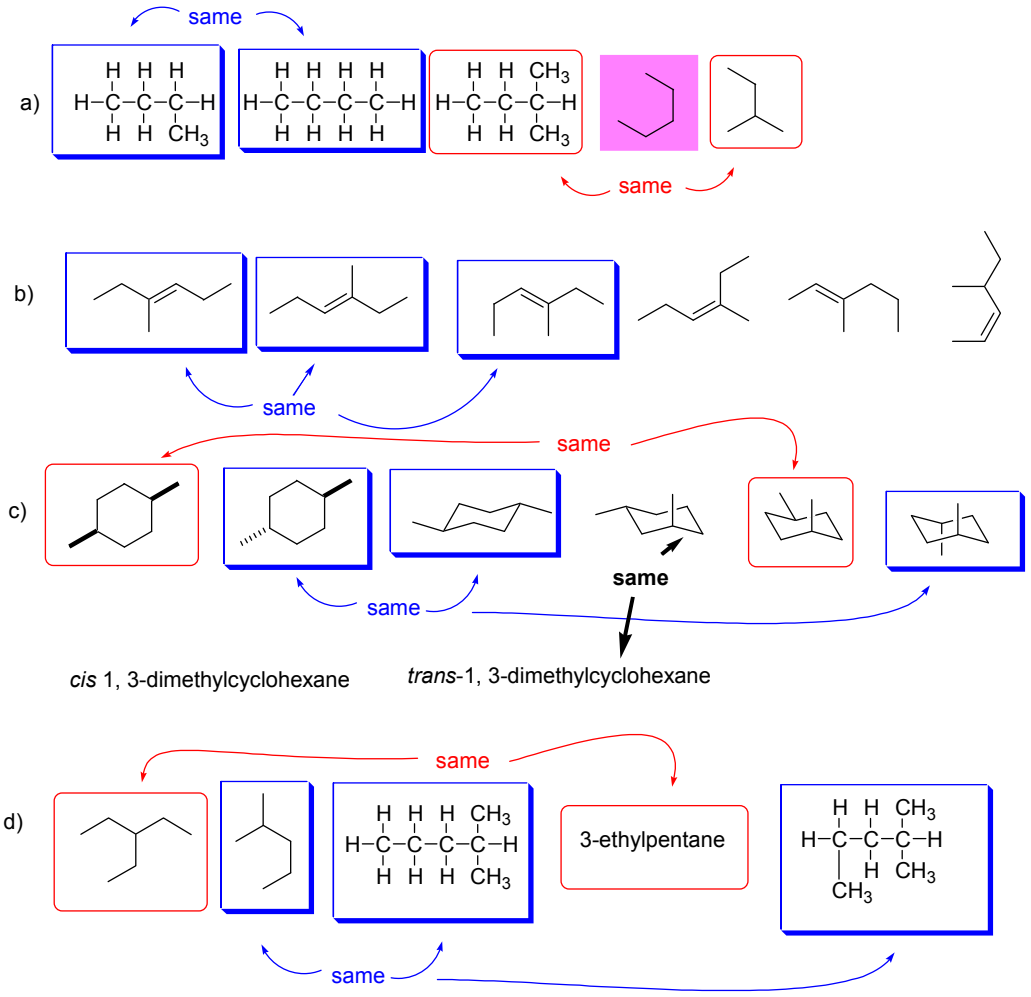
c)  2,6-Dimethyloctane

d)  5-isopropyl-4-methylnonane or 4-Methyl-5-(1-methylethyl)nonane

e)  1,3-Dimethylcyclohexane

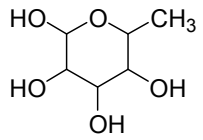
9) Which of the following represent different compounds? Which represent the same compound?

(molecules that are the same in each part are grouped with similar shaped and colored boxes)

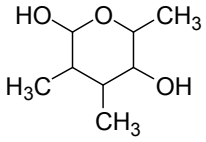


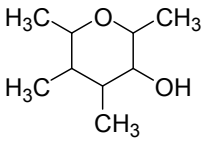
10) Predict which of the following in each set of compounds will have the highest water solubility. Which will have the lowest? Explain your answers.

a)



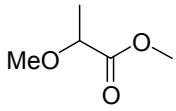
highest water solubility
most hydrogen bonds possible



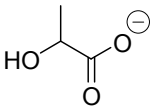


lowest water solubility
fewest hydrogen bonds possible

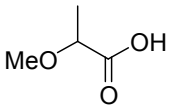
b)



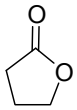
lowest water solubility
fewest hydrogen bonds possible

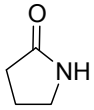


highest water solubility
charged species have very strong
dipole interactions (ionic). This makes
for strong interactions with water.



c)





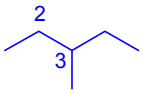
highest water solubility
most hydrogen bonds possible

lowest water solubility
no hydrogen bonds possible

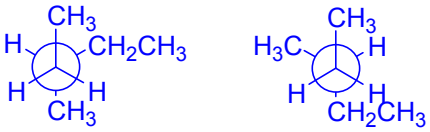
11) Use a Newman projection, about the indicated bond, to draw the most stable conformer for each compound. What is the least stable conformer of each?

Only one set of answers are shown. There are many ways to draw a Newman projection. It does not matter which side of the bond you draw the projection from. The angle of the front carbon on the paper does not matter. What is important is whether groups are eclipsed or staggered, the attachment of substituents to the bond in question, and the proper angles between substituents on a given carbon. If you are unsure, check with your TA or Prof.

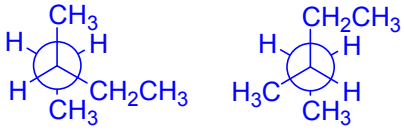
a) 3-methylpentane about the C2-C3 bond.




Newman projections C2 in front



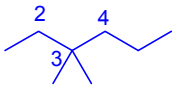
Newman projections C2 in back



Best conformers (Anti Staggered)
(Energies similar,
but slight preference for ethyl in anti position)

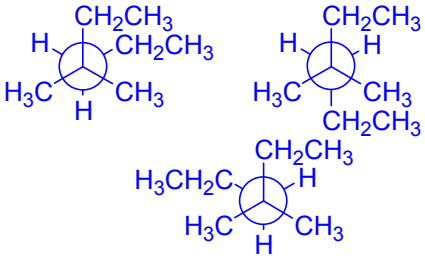
Worst conformers (Alkyl groups eclipsed)
(Energies similar)

b) 3, 3-dimethyl hexane about the C3-C4 bond

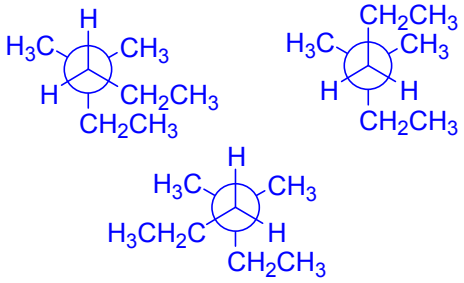



Best conformers (Anti Staggered)
(Energies similar)

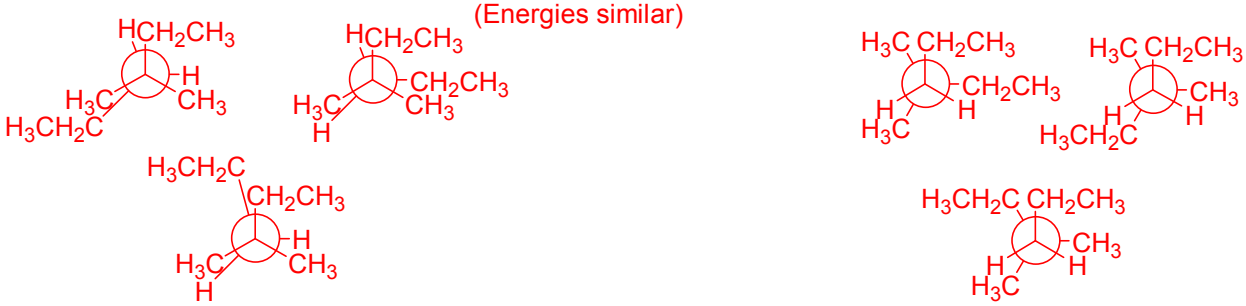
Newman projections C3 in front



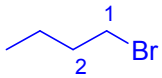
Newman projections C3 in back



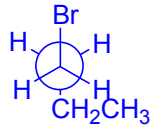
Worst conformers (Alkyl groups eclipsed)
(Energies similar)



c) bromobutane about the C1-C2 bond

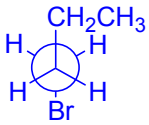


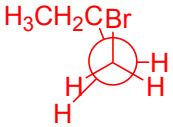

Newman projections C1 in front



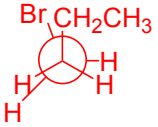

Best conformer (Anti Staggered)

Newman projections C1 in back

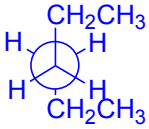


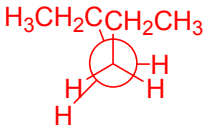

Worst conformer (large groups eclipsed)




d) 

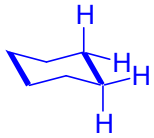


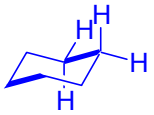

Best conformer (Anti Staggered)



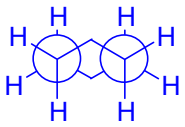

Worst conformer (large groups eclipsed)

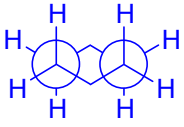
e) 

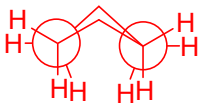



Best conformers (Staggered)
Chairs



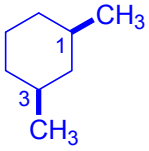



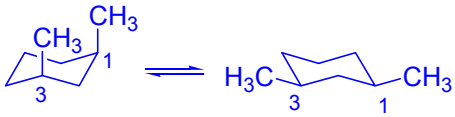




Worst conformer (eclipsed)
(Boat, view is of bond shown)

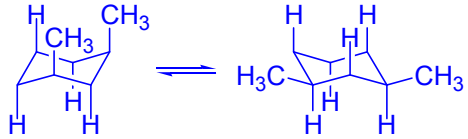
12) Consider *cis*-1,3-dimethylcyclohexane.

a) Draw the two chair conformations using line notation.

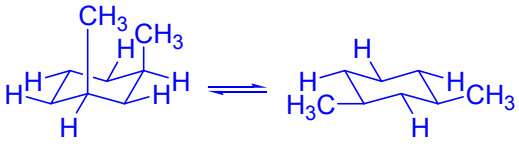


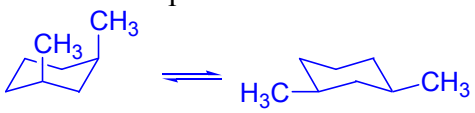

b) Re-draw the two chair conformations showing all the axial hydrogens.




c) Re-draw the two chair conformations showing all the equatorial hydrogens.




d) Label the high and low energy conformers in part a

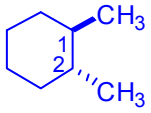


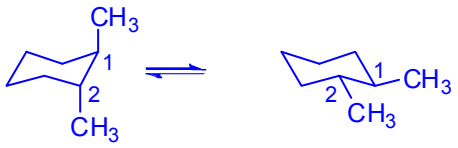

High Energy
(Both Me's axial)

Low Energy
(Both Me's equatorial)

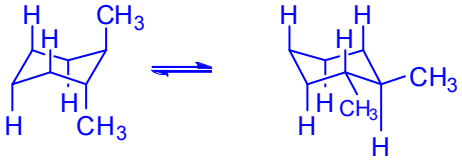
note: Me = $CH_3$

13) Repeat question 9 for *trans*-1,2-dimethylcyclohexane.

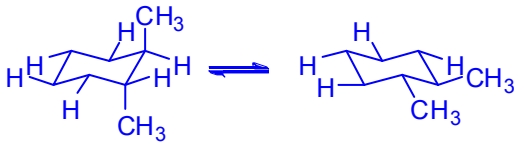



Axial H's




Equatorial H's

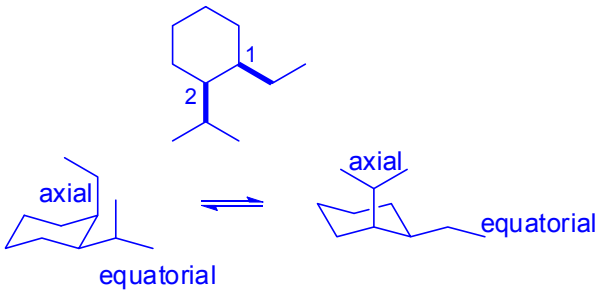



High Energy
(Both Me's axial)

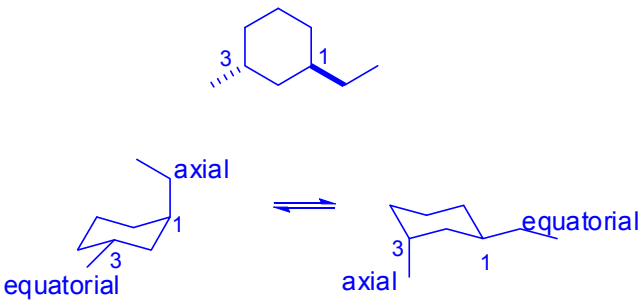
Low Energy
(Both Me's equatorial)

14) Draw the two chair conformations of each compound listed below. For each structure, label the substituents (groups other than hydrogen) as being axial and equatorial.

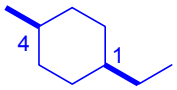
a) *cis*-1-ethyl-2-isopropylcyclohexane

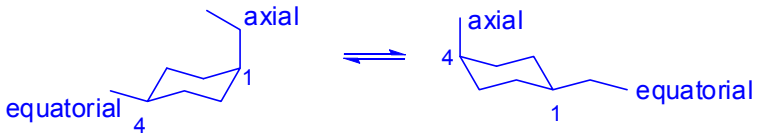



b) *trans*-1-ethyl-3-methylcyclohexane

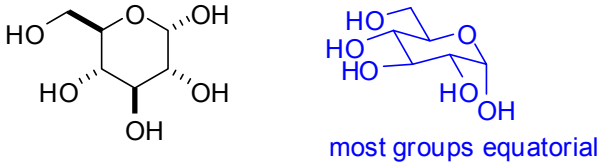


c) *cis*-1-ethyl-4-methylcyclohexane

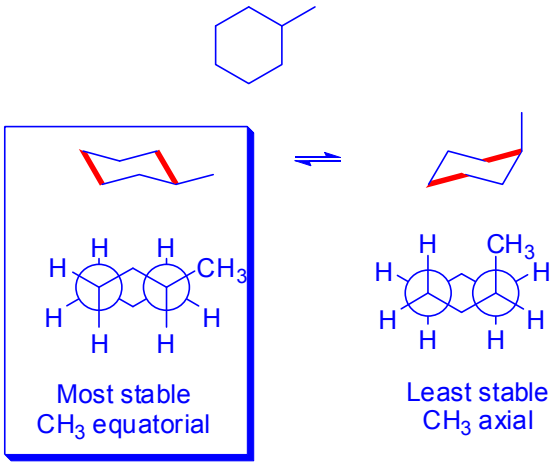


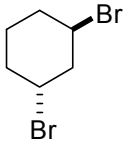

15) Draw the most stable form of glucose.

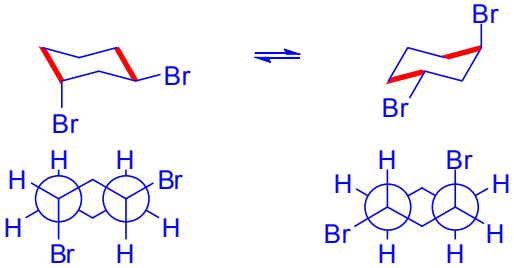



16) Draw the Newman projection of methylcyclohexane about the C1-C2 bond for the most stable and least stable chair conformers. Clearly identify which is which, and briefly justify your choice.
(Bonds in Newman projection are shown in red on the chairs. Note that these are the same bonds in each structure)




17) Draw the Newman projections of the two chair conformations of trans-1, 3-dibromocyclohexane (hint check out figure 4-6). Identify the most and least stable conformers (if any).




Chairs equal energy - each has 1 equatorial and 1 axial bromine

**Note:** heavy bonds are shown in projections above