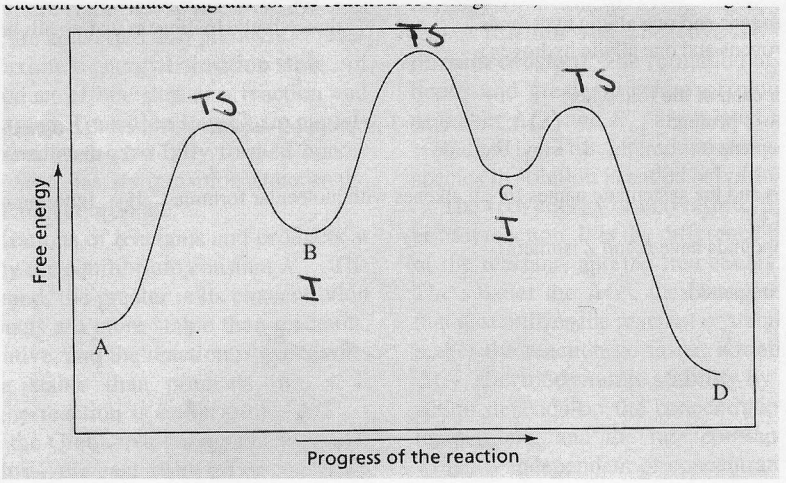
1) (7 pts) Given the following reaction coordinate diagram for the reaction of A to give D, answer the following questions:



a. How many intermediates are there in the reaction? Identify them with an **I** on the diagram. 2

b. How many transition states are there? Identify them with a **TS** on the diagram. 3

c. What is the fastest step in the reaction?

C-D

d. Which is more stable, A or D?

D

e. What is the reactant of the rate-determining step?

A

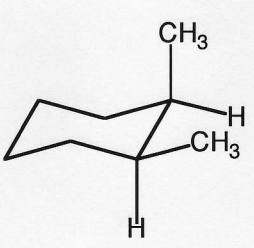
f. Is the first step of the reaction exergonic or endergonic?

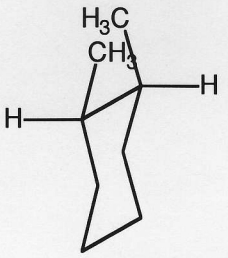
endergonic

g. Is the overall reaction exergonic or endergonic?

exergonic

2) (5 pts) What are the dihedral angles between the methyl groups in the following two compounds.

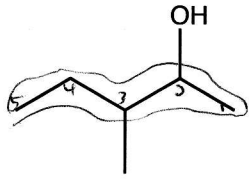




60° 60°

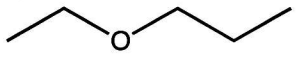
3) (20 pts) Provide either the name or the structure for the following compounds.

(a)



3-methyl-2-pentanol

(b)

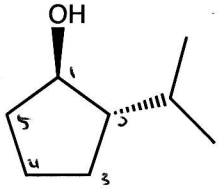


ethyl propyl ether

(c)

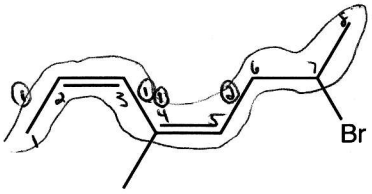
N-methyl-1-pent-4-enamine

(d)



Trans-2-isopropyl-1-cyclopentanol

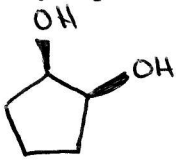
(e)



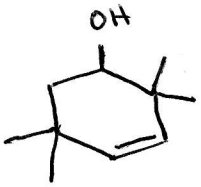
(2Z,4Z)-7-bromo-4-methyl-2,4-octadiene

(f) *tert*-Butylamine

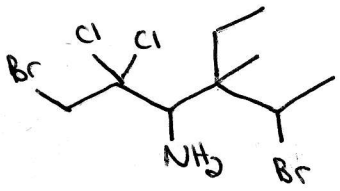
(g) *cis*-1,2-Cyclopentanediol



(h) 2,2,5,5-Tetramethylcyclohex-3-enol



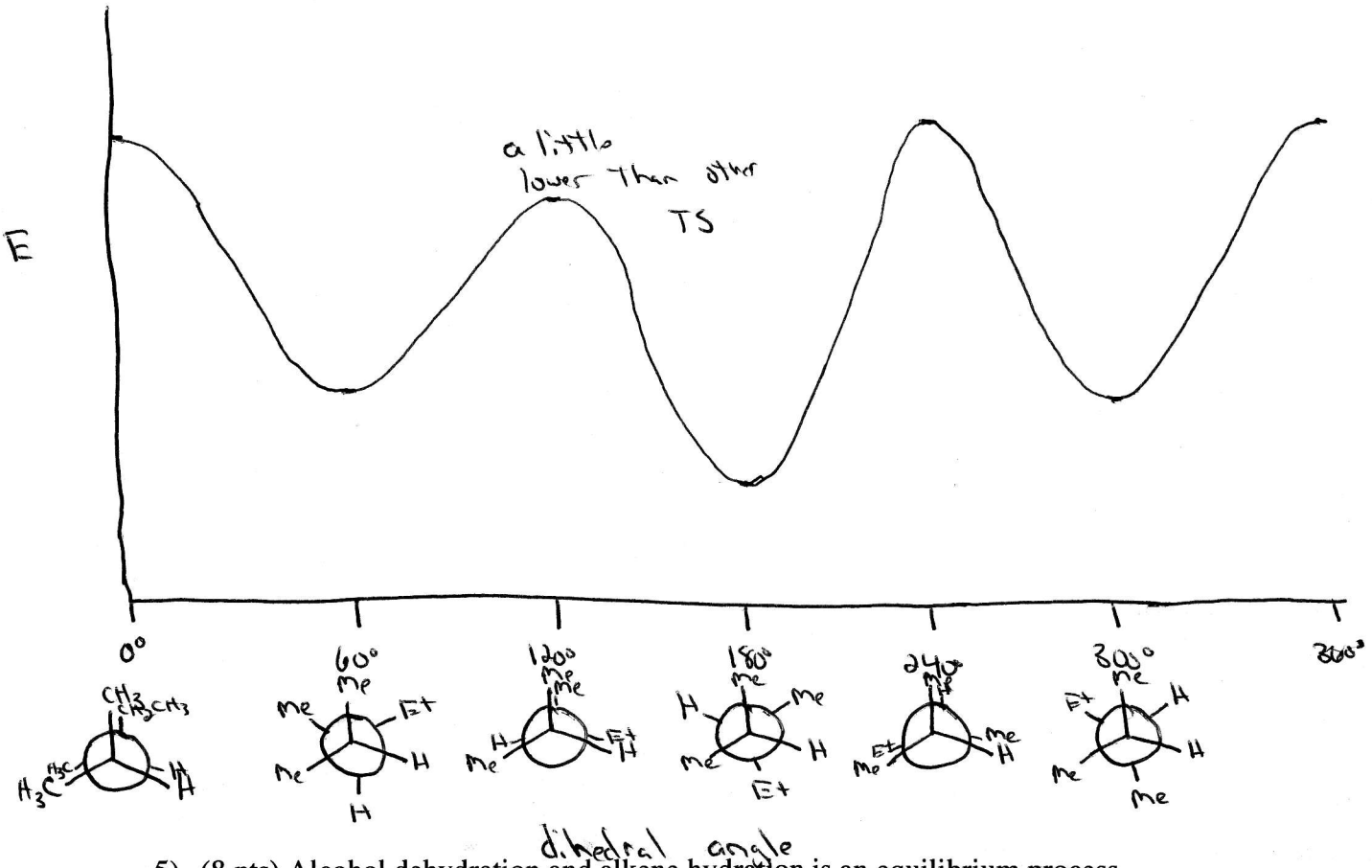
(i) 1,5-Dibromo-2,2-dichloro-4-ethyl-4-methyl-3-hexanamine



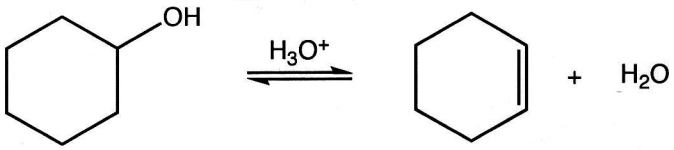
(j) (*E*)-2-pentene

7
Substituent numbers

4) (12 pts) Draw an energy versus dihedral angle plot for the conformations of 2,3-dimethylpentane about the C2–C3 bond.



5) (8 pts) Alcohol dehydration and alkene hydration is an equilibrium process.



(a) Suggest experimental conditions that will favor cyclohexene.

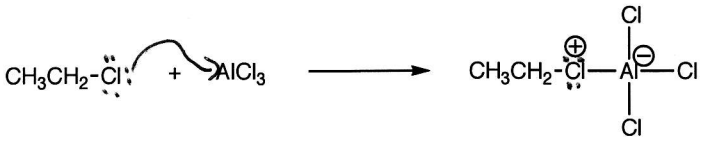
better: remove H_2O or add cyclohexanol
or
remove cyclohexene

(b) Suggest experimental conditions that will favor cyclohexanol.

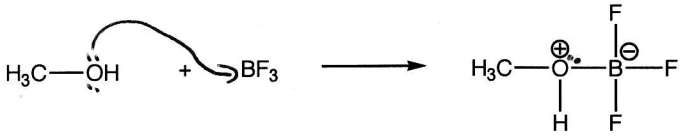
remove cyclohexanol or add water better
or
add cyclohexene

6) (7 pts) Draw the curved arrow mechanisms for the following transformations. Also designate the Lewis acid and Lewis base in each reaction. Be sure to add any needed lone pairs to the structures. Just add the arrows and lone pairs to the provided drawings.

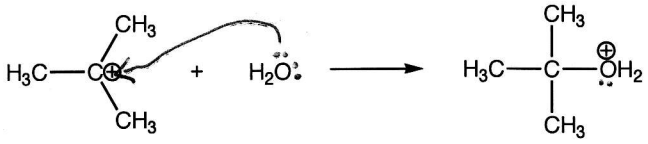
a)



b)



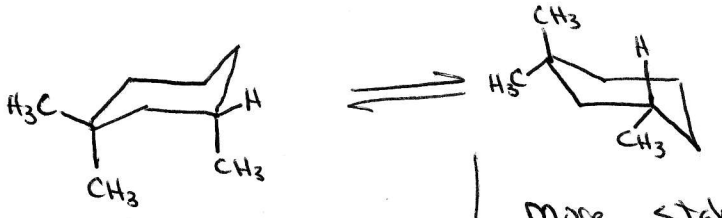
c)



7) (10 pts) It is often said that the *tert*-butyl group locks the molecule into the form with the *tert*-butyl group equatorial. Is this a good way to put it? Why or Why not?

Not really. "Lock" implies that it can't move or adopt any ~~other~~ geometries/positions. This is NOT the case. A cyclohexane with a t-butyl group attached can adopt a conformation with the tbutyl group axial, but it is EXTREMELY energetically favorable to have the tbutyl group in the equatorial position. Essentially the tbutyl group exist solely (99.9999 in the equatorial position but not 100%.

8) (10 pts) Draw the chair conformations of 1,1,3-trimethylcyclohexane. Which conformation is more stable? Expain. By how much energy? Be sure to calculate the strain energy for each molecule given the following information: a Me/H 1,3-diaxial interaction costs 0.9 kcal/mol, a Me/Me 1,3-diaxial interaction costs 1.8 kcal/mol, and a Me/ring gauche interaction costs 0.9 kcal/mol.



1,3-Me-Me diaxial interaction | More stable

Energy

Me-Me diaxial = 1.8 kcal/mol
2 Me-H diaxial = 2(0.9 kcal/mol)
4 Me-ring gauche = 4(0.9 kcal/mol)

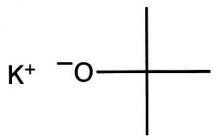
Torsional strain = 7.2 kcal/mol

2 Me-H diaxial = 2(0.9 kcal/mol)
2 Me-ring gauche = 2(0.9 kcal/mol)

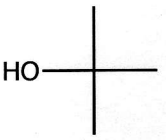
Torsional strain = 3.6 kcal/mol

Favored by 3.6 kcal/mol

9) (9 pts) Is *tert*-butoxide anion a strong enough base to react with water? In other words, can a solution of potassium *tert*-butoxide be prepared in water? Be sure to show and explain your work.



Potassium *tert*-butoxide



***tert*-butyl alcohol**

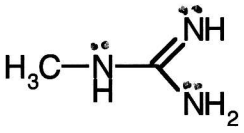
pKa 16 pKa 17

So, $K_{eq} \sim 1$

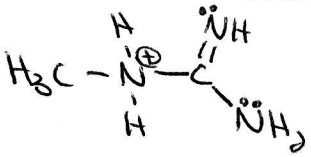
Yes, tbutoxide can react with water.

No, a solution of tbutoxide can NOT be prepared in H_2O because $K_{eq} \sim 1$

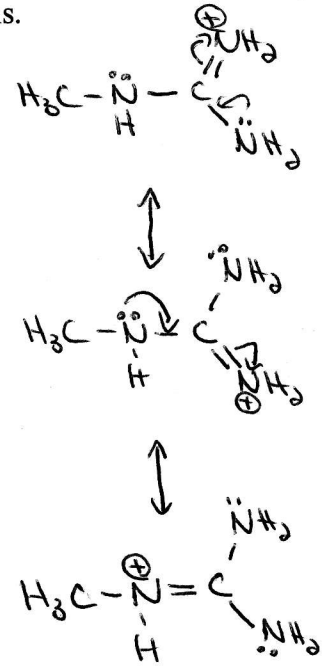
10) (12 pts) The following compound can become protonated on any of the three nitrogen atoms. One of these nitrogens is much more basic than the others, however.

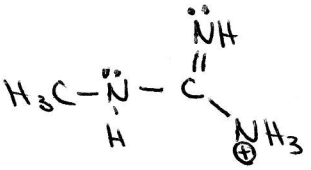


a) Draw the important resonance forms of the products of protonation on each of the three nitrogen atoms. Be sure to treat each protonation as separate, non-consecutive reactions.



No resonance





No resonance

b) Circle the nitrogen atom that is most basic.