Name: Answer Key

Chem 633: Advanced Organic Chemistry 2016 ··· Midterm 1

Please answer the following questions *clearly and concisely*. In general, use pictures and less than 10 words in your answers.

Write your answers in the space provided.

Write your initials on each page you want graded.

There are 10 total pages to this exam. The last 2 pages were intentionally left blank and may be used for scratch paper. Please be sure your copy has 10 pages before you begin.

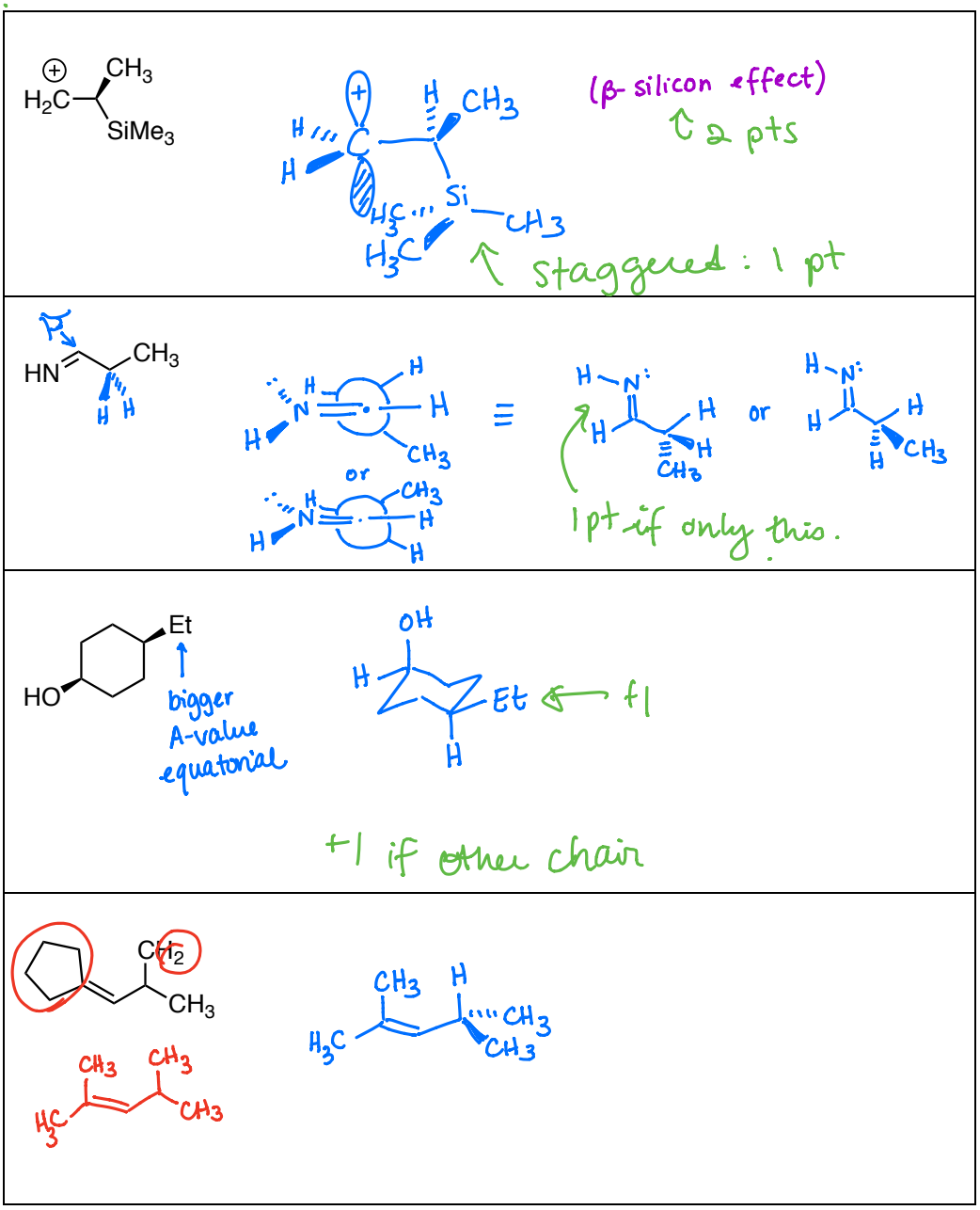
Molecular models are allowed.

Calculators are unnecessary and prohibited.

Problem	Points
1	_____/12
2	_____/18
3	_____/20
4	_____/15
5	_____/20
6	_____/15
TOTAL	_____**/100**

1. (12 points) Clearly draw the most stable conformation of the following molecules. ~~You may use Newman projections, when appropriate.~~ No explanation is necessary.

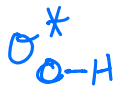
3pts each.



2. (18 points)

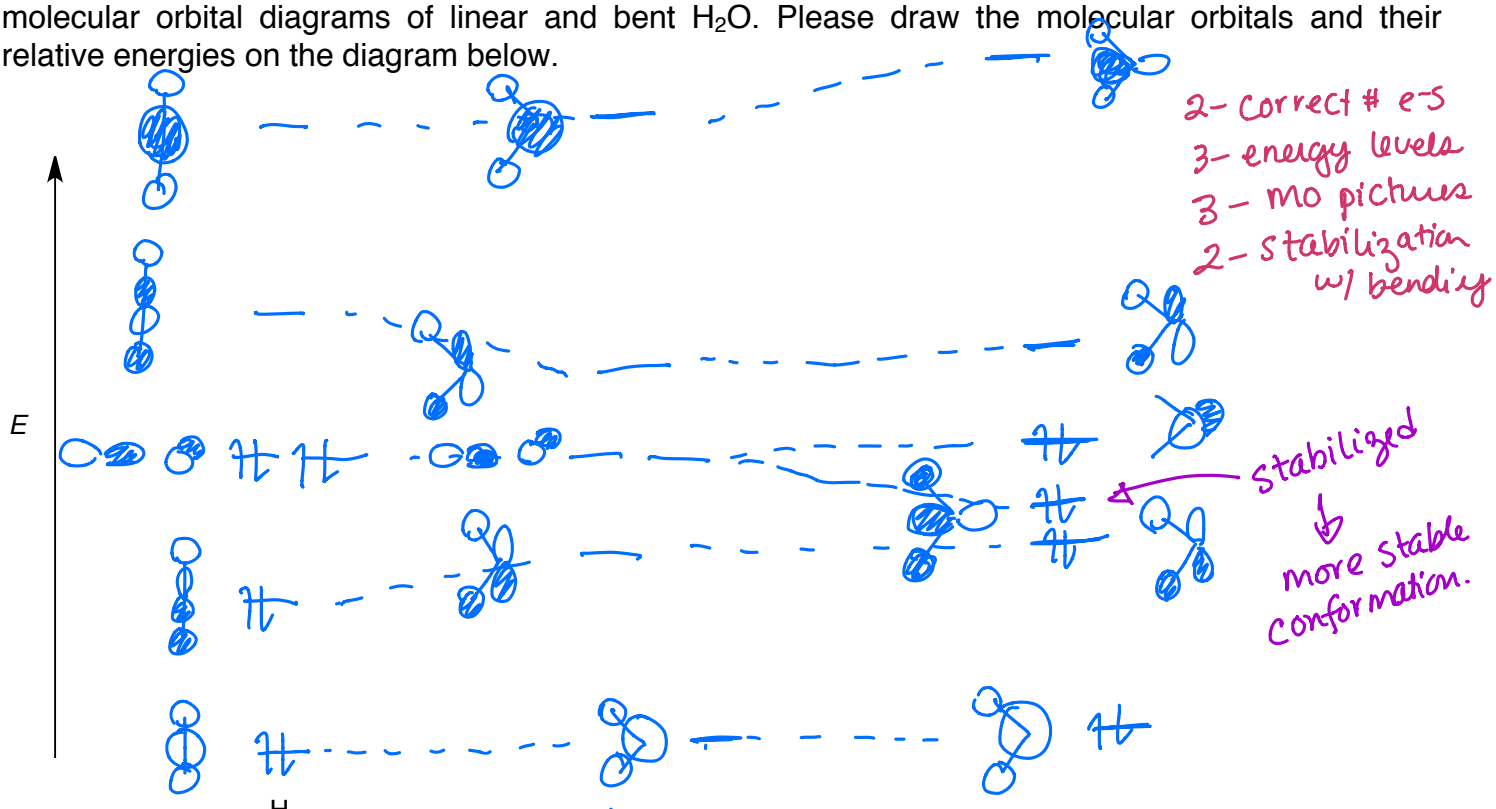
(a) Based on your chemical intuition, please name and draw the HOMO and LUMO of water (H_2O).

8 pts = 2 pts / box

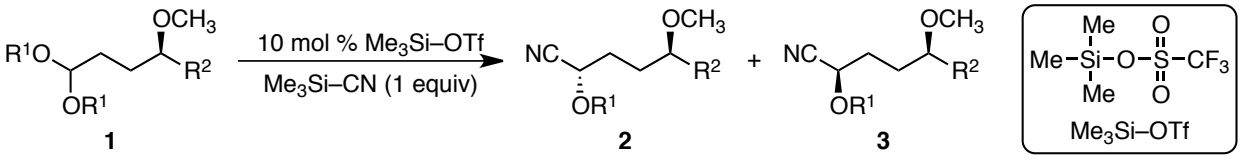
Name of HOMO of H_2O:	Picture of HOMO of H_2O:
lp_O or n_O lone pair on Oxygen (x2) 1pt for p	 1pt for p
Name of LUMO of H_2O:	**Picture of LUMO of H_2O:**
	

10 pts

(b) Please rationalize why H_2O is bent using Molecular Orbital Theory. Your answer should include molecular orbital diagrams of linear and bent H_2O. Please draw the molecular orbitals and their relative energies on the diagram below.



3. (20 points) Molander reported the following useful method for the stereoselective formation of product **2** (*JACS* **1991**, *113*, 3608). In this reaction, Me_3SiOTf acts as a catalytic Lewis acid. Importantly, the OCH_3 group is *critical* for diastereoselectivity.



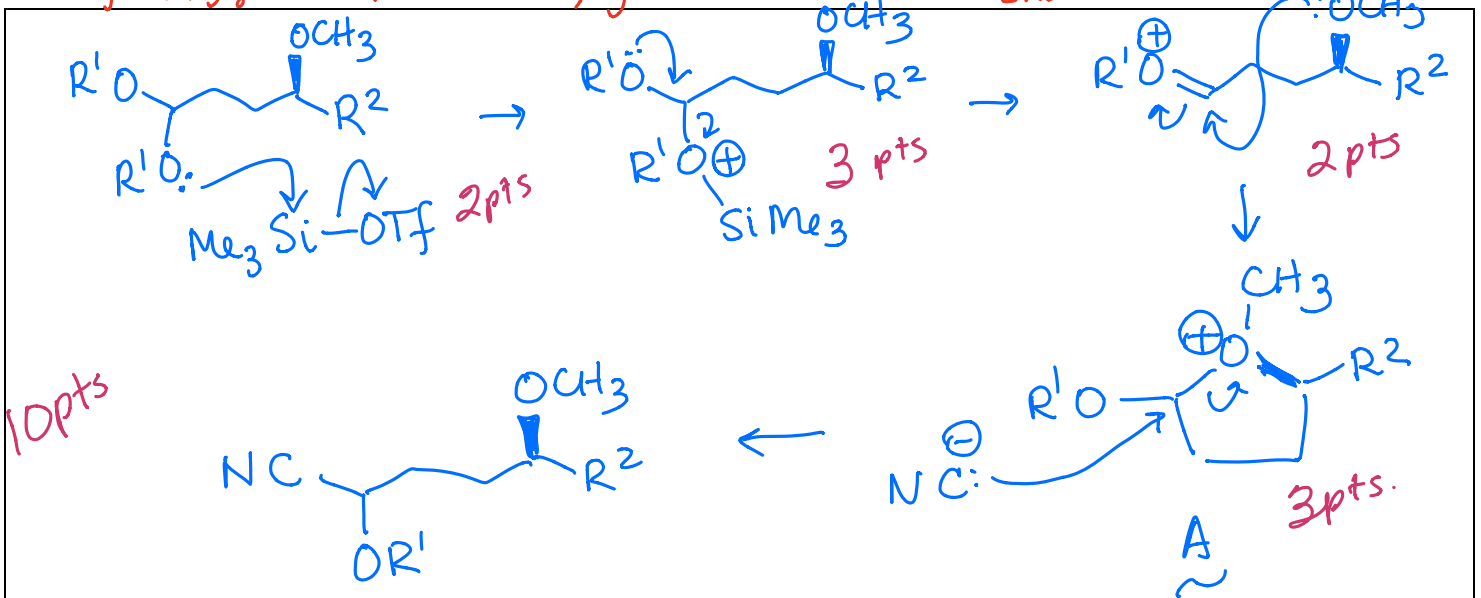
Where Si is the Lewis acidic atom and OTf is a leaving group.

R^1	R^2	Ratio of **2** : **3**
Me	Me	1.5 : 1
i-Pr (*i*-Pr = $CHMe_2$)	Me	5 : 1
i-Pr	*i*-Pr	15:1

(a) What type of stereoisomers are **2** and **3**?

5 pts. diastereomers

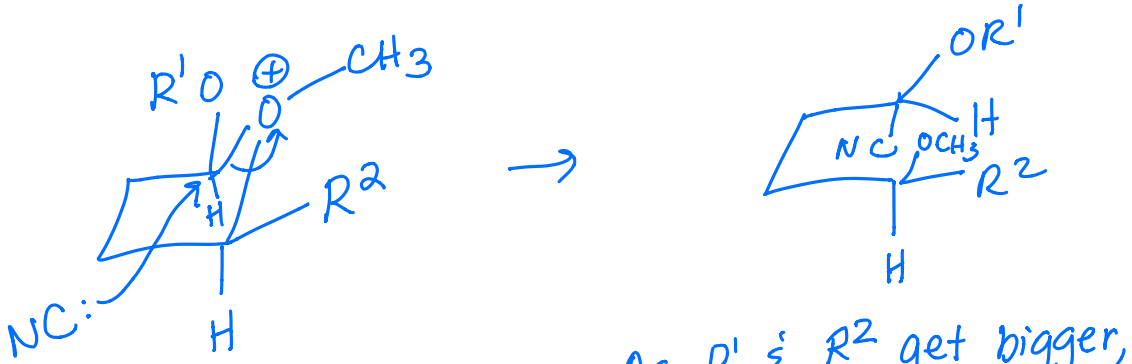
(b) Please draw a reasonable arrow-pushing mechanism for the transformation of **1** to **2**. Be sure your answer includes an explanation for the role of the OCH_3 group. You may assume TMS CN hydrolyzes to form $^{\ominus}CN$; you do not need to show this step.



(3 – continued)

(c) Please explain the observed stereoselectivity, including the trend shown in the table. Your answer should include clearly drawn structures and less than 10 words. (Hint: The stereoselectivity is not dependent on the relative stability of the products.)

5 pts.

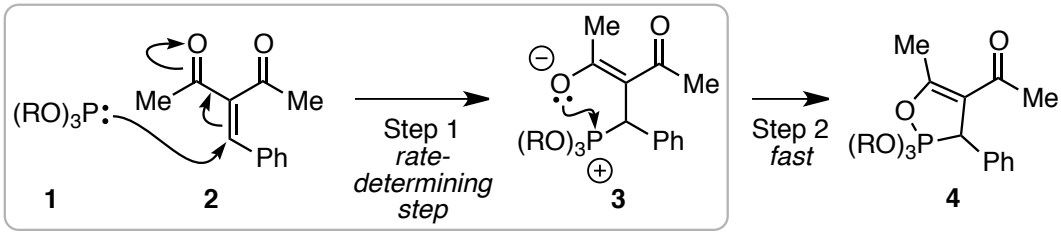


lowest energy conformation of A

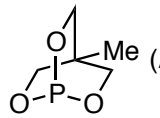
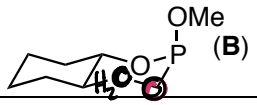
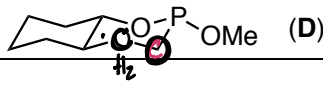
As R' & R^2 get bigger, the lowest energy conformation is more greatly favored.

2pts: OR' seeks to minimize steric clash w/ R^2

4. (15 points) Phosphites (**1**) are known to undergo 1,4- additions to α,β-unsaturated carbonyls (**2**), ultimately resulting in the formation of phosphorane **4**. The rate of this reaction depends on Step 1, so you only need to consider Step 1. Please explain the relative rates of the phosphites shown in the table. Hint: Because you are considering what would stabilize the transition state, you can consider either the forward (**1**+**2** –> **3**) or the reverse (**3** –> **1**+**2**) reaction.

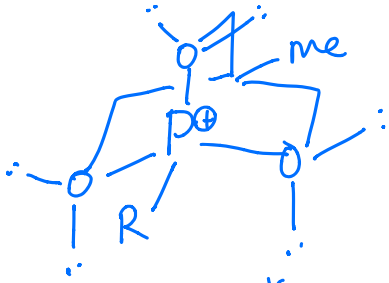


I will throw this problem out. Sorry!!

Phosphite	Relative Rate
 (**A**)	1
 (**B**)	125
$P(OEt)_3$ (**C**)	250
 (**D**)	750

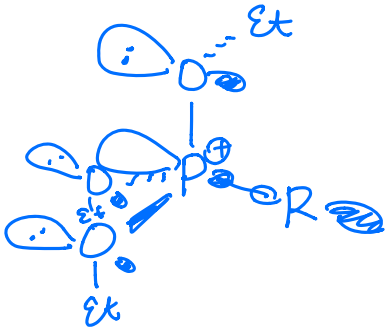
Typo (Aack!)

Consider reverse rxn... $lp_O \rightarrow \sigma^*_{P-C}$ weakens P-C bond & accelerates rxn.

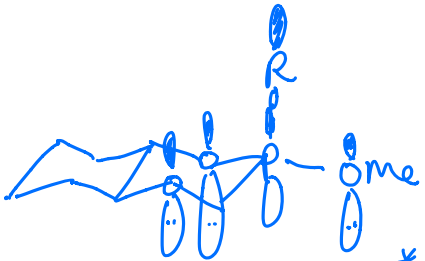


no $lp_O \rightarrow \sigma^*_{P-C}$ possible

1 $lp_O \rightarrow \sigma^*_{P-C}$



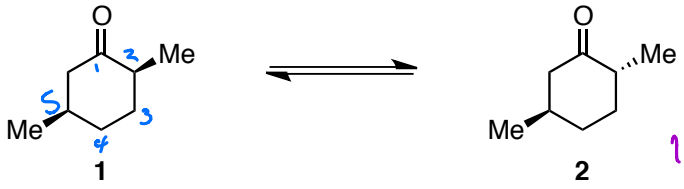
Up to 3 $lp_O \rightarrow \sigma^*_{P-C}$ possible (but not enforced)



Up to 3 $lp_O \rightarrow \sigma^*_{P-C}$ & 2 enforced geometrically.

+5 : anomeric effect

5. (20 points) For this question, please consider the equilibrium of **1** and **2**.

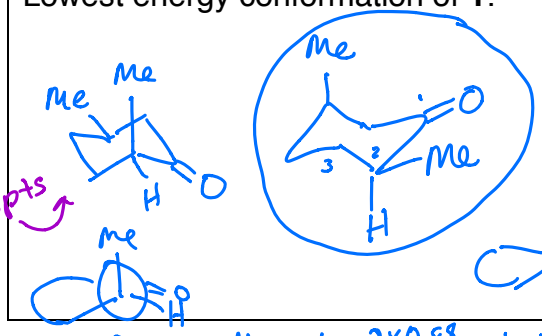


1 pt / box for pretty chairs (even if wrong isomer)

(a) Please draw the lowest energy conformations of **1** and **2**.

5pts

Lowest energy conformation of **1**:

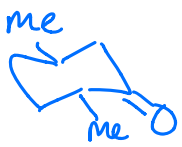


~0.5 kcal/mol

2 1,3 me-H diaxials = 2×0.88 | 1 1,3-me-H diaxial = 1×0.88

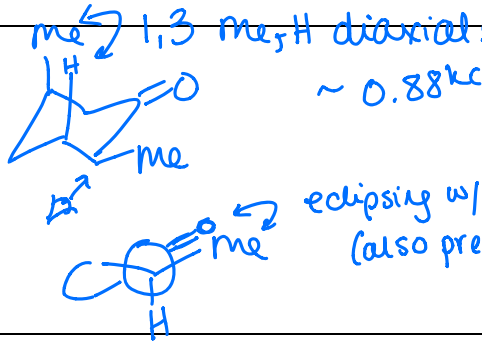
5pts

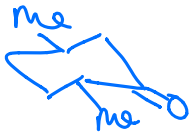
Lowest energy conformation of **2**:



(b) Based on values we discussed in lecture, please predict an *approximate* ΔG° for this equilibrium. Please clearly explain your reasoning (remember: a picture is worth 1000 words!).

5pts





no 1,3 diaxials.

$\Delta G^\circ \approx -0.88$ kcal/mol

(c) Please clearly describe the experiment and data analysis you would do to experimentally determine ΔG°, ΔH°, and ΔS° for this equilibrium.

5pts

1pt

① measure [2] & [1] at various temperatures (could use NMR).

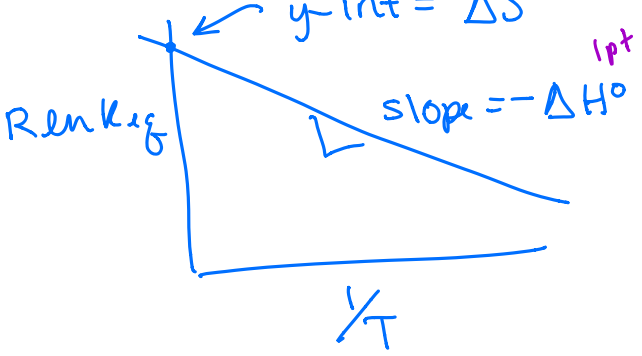
② convert to $K_{eq} = \frac{[2]}{[1]}$.

③ Plot $R \ln K_{eq}$ vs. $1/T$ 1pt

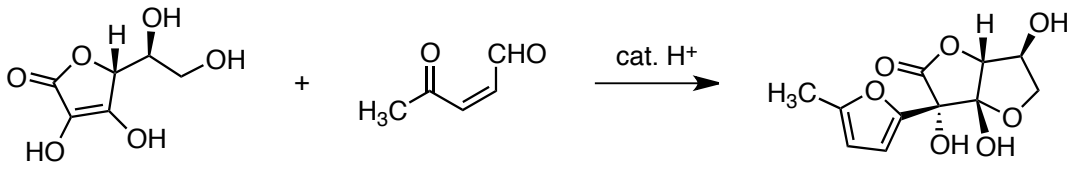
④ slope = $-\Delta H^\circ$.

⑤ y-int = ΔS°

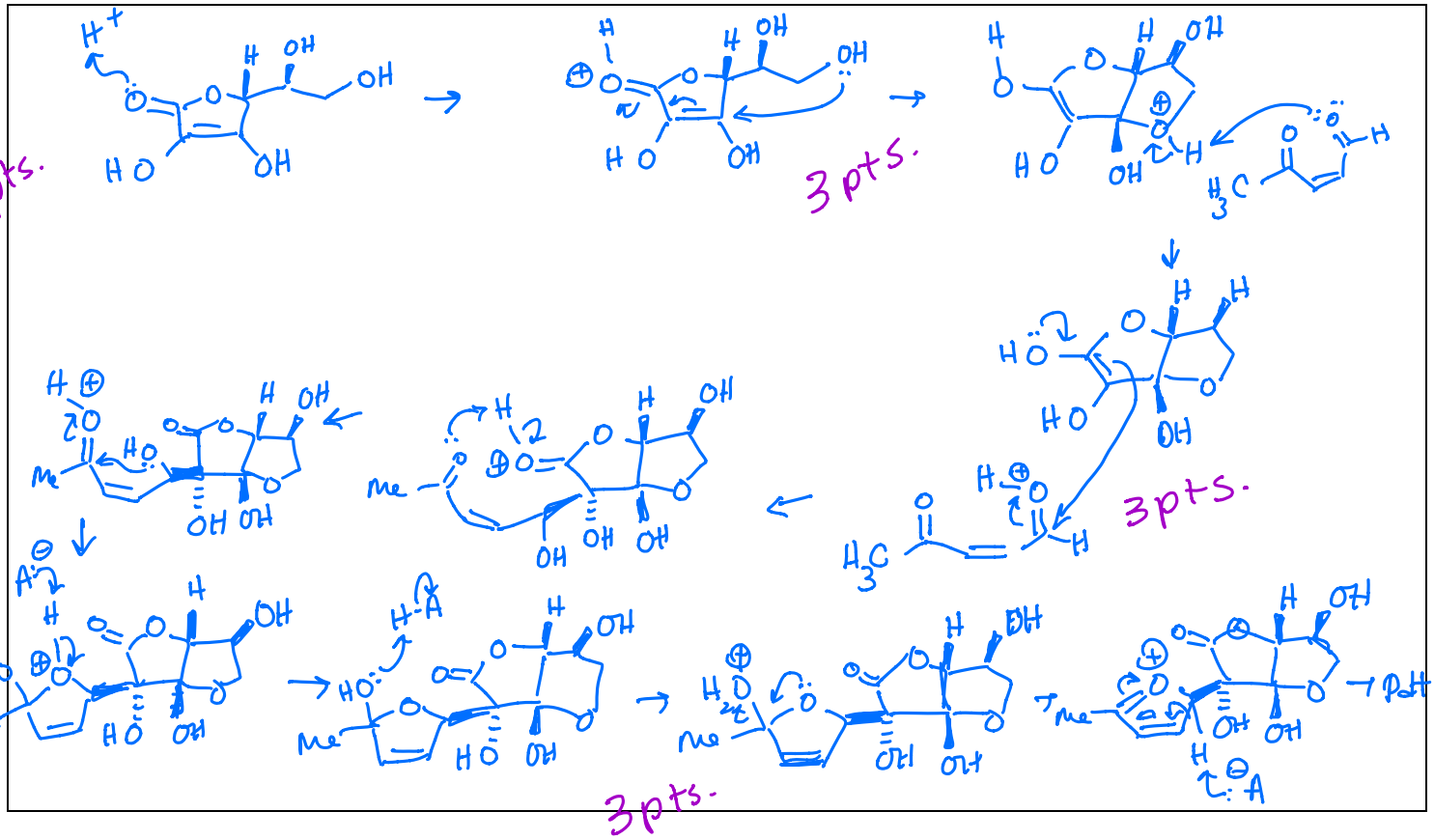
⑥ $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ 1pt



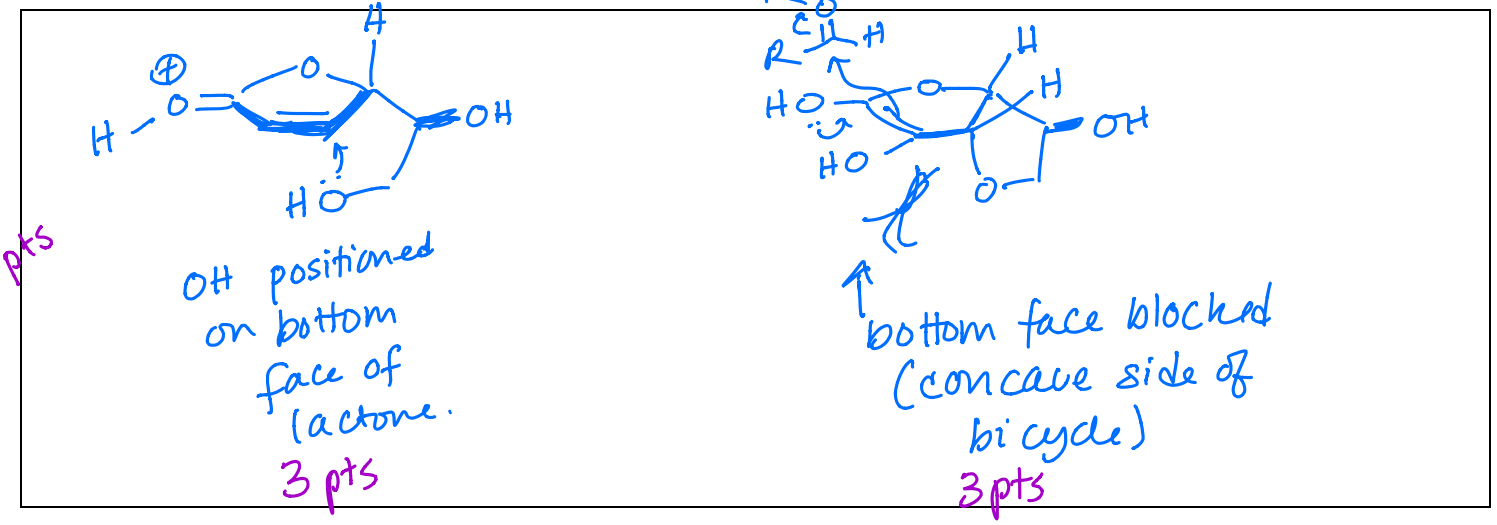
6. (15 points) (a) Please draw a reasonable arrow-pushing mechanism for the following reaction (Grossman, Chapter 3, #4i).



1 **2** **3**



(b) Please explain the stereochemistry of the new stereocenters formed in the product.



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