Organic Cumulative Examination
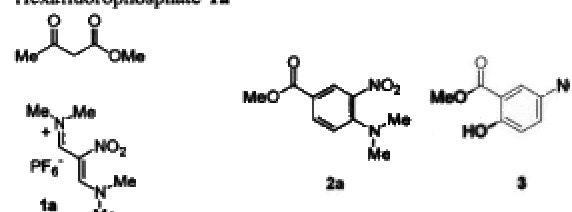## February 2, 2002

I.   (12) Basic material

1. The Hammett Acidity Function is used for studying reactions in what kind of solution? Explain.

2. Is the nitration of benzene compared to hexadeuterobenzene expected to show a primary deuterium kinetic isotope effect? (Explain)

II. Applications

1. The transformation to be discussed was taken from Org. Lett. **2002** *4* 439-441 but a knowledge of this paper is not at all necessary to answer the questions. In fact, it is only used as a modern template to test your knowledge and frame the questions.

Table 1. Reaction of MAA and 2-Nitrovinamidinium Hexafluorophosphate 1a

entry	solvent	base	% yield 2a	% yield 3	ratio 2a
1	THF	KO^{t}Bu	78	9	9:1
2	DMF	KO^{t}Bu	65	14	5:1
3	CH$_3$CN	KO^{t}Bu	70	14	5:1
4	MeOH	KO^{t}Bu	70	9	8:1
5	MeOH	NaOMe	76	5	14:1
6	THF	KOH	70	8	9:1
7	THF	LiO^{t}Bu	70	5	14:1

a Reactions were conducted at room temperature with 1.05 equiv of b and 1.1 equiv of 1a for 4 h. Assay yield was determined by HPLC analy
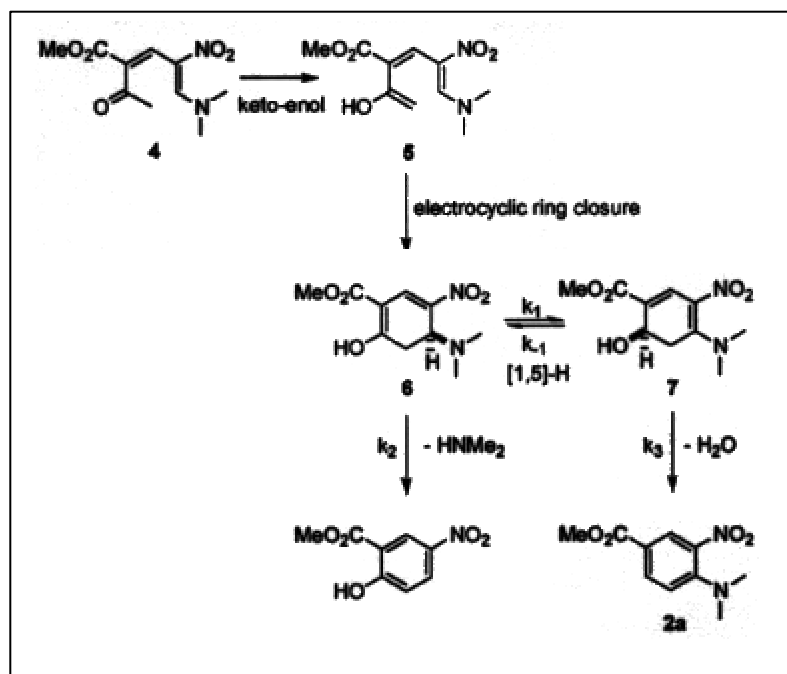
1. (10) Write a mechanism for the conversion of **1a** to **4**. Note that the reaction is catalyzed by the types of bases shown in Table 1.

2. (15) Suppose that the structure of 1 is changed to provide the intermediate **8**. Assume that the rates of product formation are measured for a series of substituted (X) compounds, and assume that the conversion of 8. which replaces 4, to the analog of **5** is rate determining. Suppose further that a Hammett ρ value of 2.5 is observed for the reaction. In mechanistic terms, what does this tell you about the conversion **4 ®5** or **6**. Give a mechanism and relevant transition states. (The mechanism need not be that suggested by the scheme above but must be consistent with the data of this problem.)
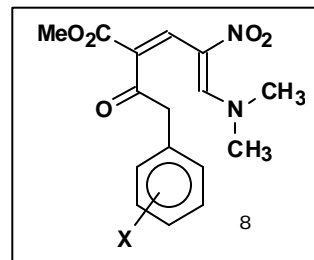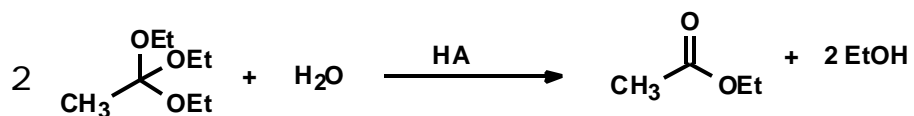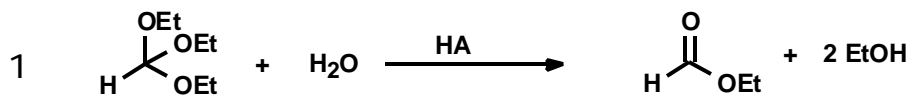

3. (10) What are possible conclusions open to the experimentalist if the ρ value of the reaction as measured is close to 0. Remember that we are measuring the rate of final production formation and that we are making no assumptions.

4. (6) Assume again that a compound yielding the series **8** is being used in the study. If either the conversion 5→6 or 6→7 (discuss separately) were rate determining, what would you expect to observe in terms of the magnitude and sign of ρ? Discuss.

5. (10) Carefully consider the overall transformation with its many steps. If we use **8** what do you think will be the relative sign and size of ρ. Using mechanism and words carefully justify your answer.

6. (4) What will be the sign and relative magnitude of $\Delta S^{\ddagger}$.

III. Many years ago using a relatively crude, but accurate, method for following transformations, Bronsted and hiss students examined the rates and effects of changes in pH and buffer concentration on the two transformations shown.

1    $H-C(OEt)_3$ (triethyl orthoformate) + H_2O $\xrightarrow{\text{HA}}$ $H-C(=O)OEt$ + 2 EtOH

2    $CH_3-C(OEt)_3$ + H_2O $\xrightarrow{\text{HA}}$ $CH_3-C(=O)OEt$ + 2 EtOH

The following results were obtained. The pH was changed in the usual way by varying the ratio of $[HA]/[A^-]$ in the acidic region. When the rate constants k_{obs} for either of the transformations were plotted against the $[H^+]$ a linear plots with a well defined plots with positive slopes were obtained were obtained. A series of experiments were performed with each of the two substrates. At a given pH, the absolute concentrations of $[HA]/[A^-]$ (buffer concentrations) were varied. In the case of reaction 1 thee was no change in the observed rate constant as this was done. On the other hand, the observed rate constants obtained for reaction 2 increased linearly as the buffer concentration increased at a single pH. This phenomenon was observed at moer than a single pH value.

Answer the following questions.
1. (3) Both reactions are showing what kind of catalysis?

2. (6) The buffer experiments show that each reaction exhibits a different for of catalysis. What names are given to these types of catalysis? Specify the type for each reaction.

3. (16) For each transformation give a mechanism which is consistent with the experimental results obtained. Make sure that you show the composition and nature of the transition state for the rate-determining step of each.

5. (8) In terms of the differing structure of the substrates, rationalize why the two forms of catalysis are different.