CHEM 343 – Principles of Organic Chemistry II – Summer 2014

Instructor: Paul J. Bracher

Hour Examination #3

Tuesday, July 22nd, 2014

8:00–9:15 a.m. (in class)

Student Name (Printed)	Solutions
Student Signature	N/A

Instructions & Scoring

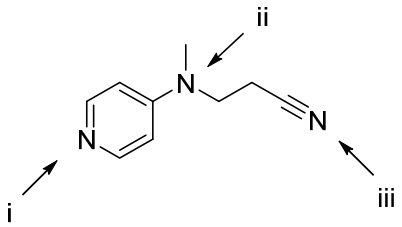
- Please write your answers on the official answer sheet. No answers marked in this booklet will be graded.
- You may use one sheet of handwritten notes and a plastic model set. You must turn in your notes with your examination.
- You may not communicate with others during this examination, and you may not access electronic devices.
- Your exam answer sheet may be photocopied.

Problem	Points Earned	Points Available
I		35
II		22
III		25
IV		18
TOTAL		100

Questions, Required Information, Supplementary Information

Problem I. Multiple choice (35 points total; +5 points for a correct answer, +1 point for an answer intentionally left blank, and 0 points for an incorrect answer). For each question, select the best answer of the choices given. Write the answer, legibly, in the space provided on the answer sheet.

(1) A When compound **A** is treated with one equivalent of tosic acid (TsOH, pK_a = −2.8), which of the nitrogen atoms on **A** would become protonated to the greatest extent?



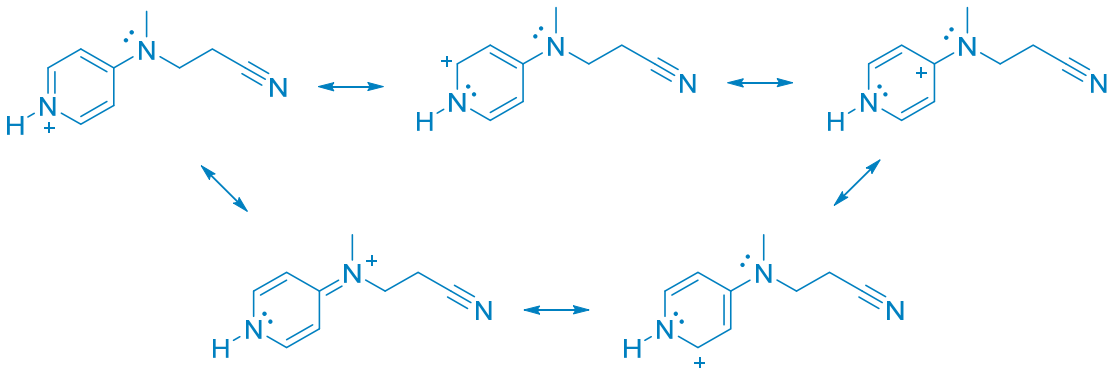
A

(a) i
(b) ii
(c) iii
(d) TsOH is not a strong enough acid to protonate compound **A**

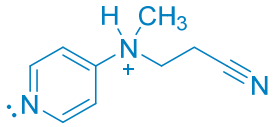
Let's start by identifying the nitrogen at "iii" as the least basic of the nitrogens present. Its lone pair is in an *sp*-hybridized orbital. For reference, the pK_a of protonated benzonitrile is −10. While the lone pair at "i" is in an orbital with more *s* character than the lone pair at "ii" (sp^2 vs. unhybridized *p*), the lone pair at "i" is orthogonal to the ring while the lone pair at "ii" is conjugated with the ring (and hence, less available). If we just consider these two competing factors, we might expect the basicities of these two lone pairs to be similar. As a point of reference, the pK_a of protonated dimethylaniline is 5.2, while that of protonated pyridine is 5.3.

But, let's take a look at the entire system put together in terms of stabilities of the conjugate acids:

Conjugate acid upon protonation at "i":

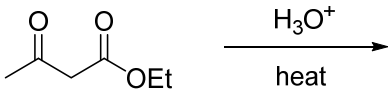


Conjugate acid upon protonation at "ii":



Protonation at "i" results in an extensively delocalized cation with five resonance structures, while protonation at "ii" results in a localized cation we would expect to be less stable. As another point of reference, the pK_a of 4-dimethylaminopyridine (DMAP) is 9.2. That's much stronger than we would expect if the aniline and pyridine nitrogens weren't "talking to each other" (in terms of an electronic effect).

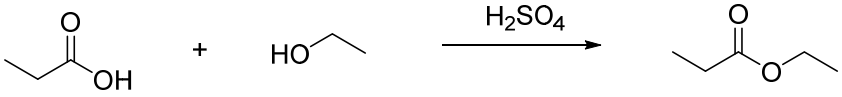
(2) C Which of the following compounds is <u>not</u> generated in significant yield when ethyl acetoacetate (**B**) is heated in acidic water?



B

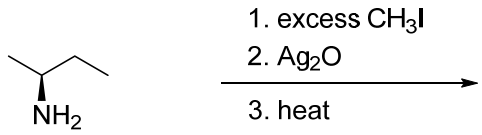
(a) ethanol
(b) acetone (2-propanone)
(c) ethanoic acid (acetic acid)
(d) carbon dioxide
(e) all of these compounds will be generated

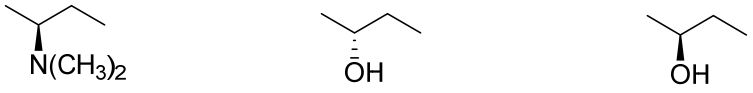
(3) B Which of the following statements is true of the reaction shown below?



(a) a polar, protic solvent like water will speed the reaction
(b) the acid serves as a catalyst
(c) the mechanism involves several anionic intermediates stabilized by a resonance effect
(d) the same product is generated when H_2SO_4 is replaced by NaOH, but the mechanism is different
(e) all of the above statements are false

(4) D What is the major product expected of the following reaction?

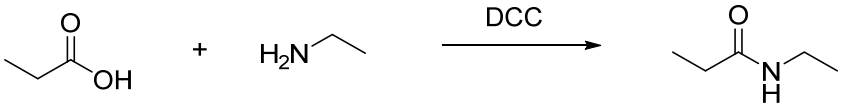




(a) (b) (c)

(d) (e)

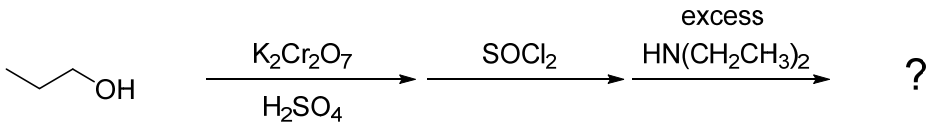
(5) B Which of the following statements is not true of the reaction shown below?

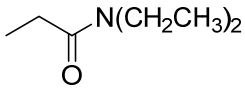


(a) the product is a secondary amide
(b) water (H_2O) is a byproduct of the reaction
(c) the amine is only a good nucleophile when its lone pair is not protonated
(d) this reaction could proceed, albeit in poor yield, if DCC were replaced with high heat
(e) the product has 5 signals in its ^{13}C NMR spectrum

- Note: water by itself (H_2O) is not a byproduct of the reaction. Rather, 2 hydrogen atoms and 1 oxygen atom add to DCC over the course of the reaction to produce dicyclohexylurea (DCU).

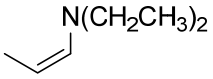
(6) A What is the product expected of the following sequence of reactions?



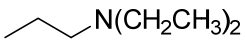


(a)

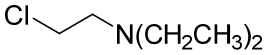
(b)



(c)



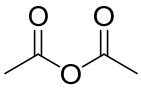
(d)



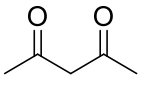
(e)

(7) B Mystery compound **C** has a single signal in its ^{1}H NMR spectrum at δ 2.2. It reacts with water, ethanol, and ethylamine to produce new products, but does not appear to react with sodium acetate. Which of the following structures is consistent with the data observed of compound **C**?

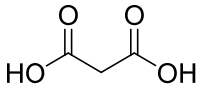
(a)



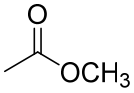
(b)



(c)



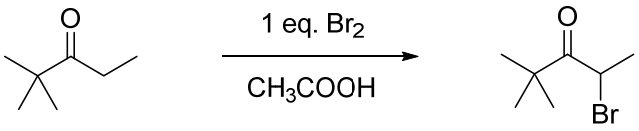
(d)



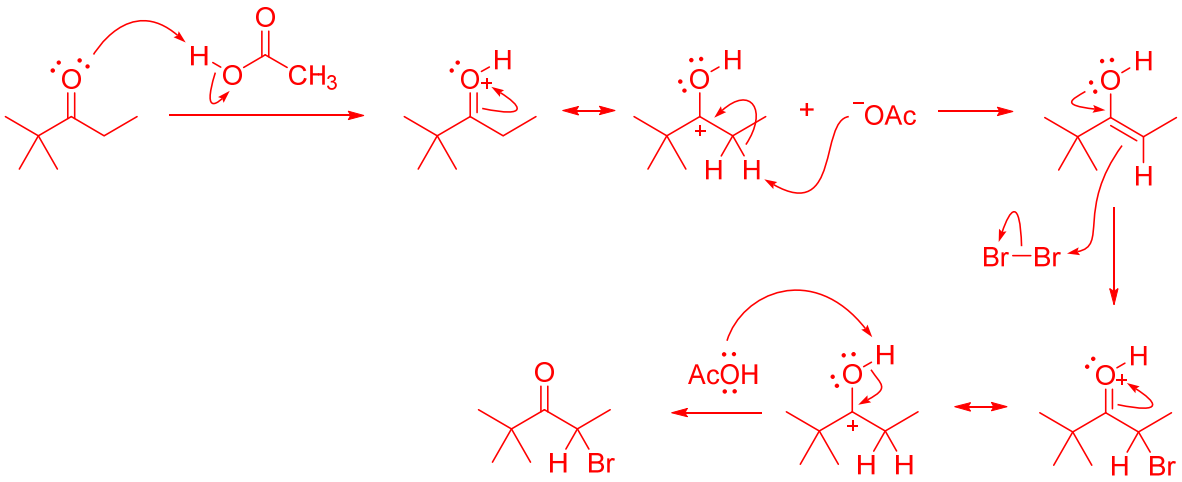
(e)

Problem II. Mechanism (22 points).

(1) (17 points) Draw a sensible mechanism for the following reaction. Remember to use proper "curved arrow notation" to account for the redistribution of electrons in the making and breaking of bonds. Show all significant resonance forms that account for the stability of the intermediates in the reaction. Pure (glacial) acetic acid serves as the solvent for the reaction and also plays a role in the mechanism.

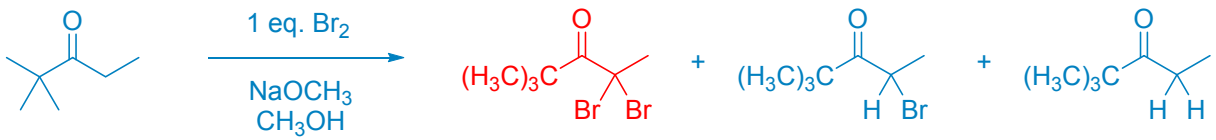


D **E**



E

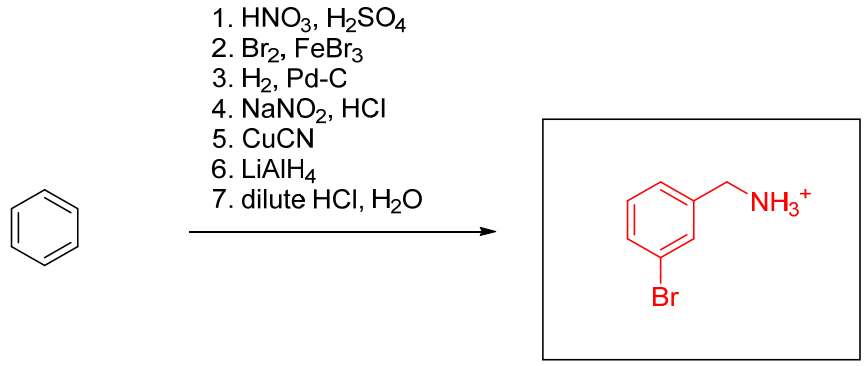
(2) (5 points) When the medium for the reaction of **D** with one equivalent of Br_2 is changed from glacial acetic acid to methanol containing sodium methoxide ($NaOCH_3$, CH_3OH), the conditions produce a major product different from **E**. Draw the structure of this different product.



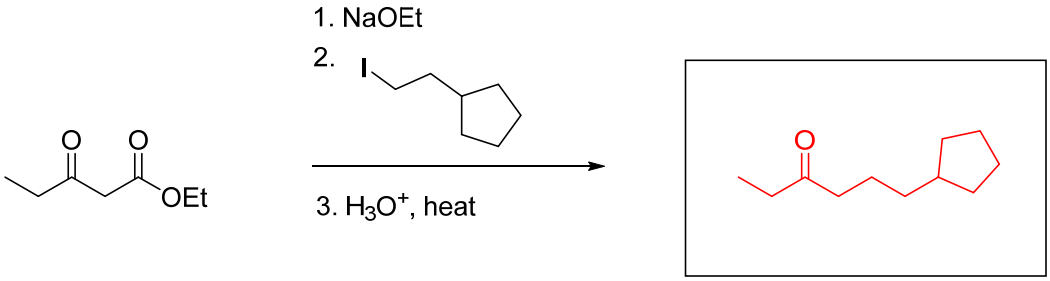
D (major) **E** (minor) **D** (no reaction)

Problem III. Reactions (25 points). The following chemical reactions are missing their starting materials, products, or reagents. Write the missing compounds into the empty boxes below, as appropriate. For missing products, draw the single organic product that you expect to be produced in the highest yield among all of the possibilities. In some cases, there will be more than one correct answer that will merit full credit.

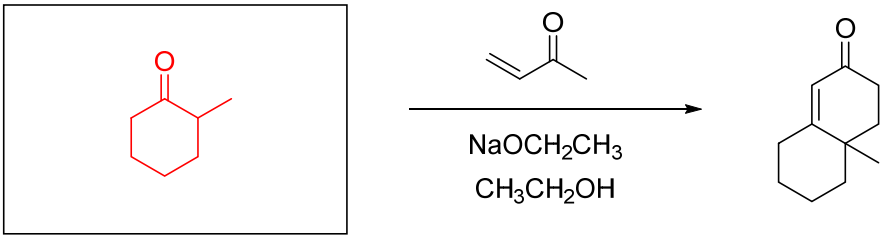
(1) (9 points)



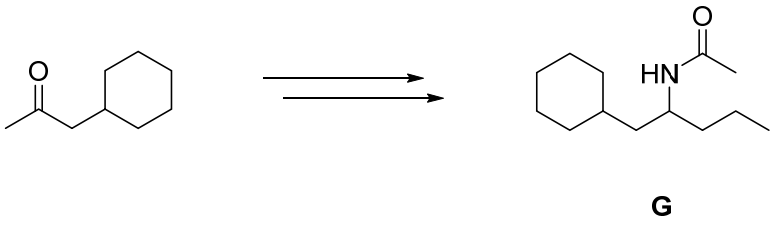
(2) (7 points)



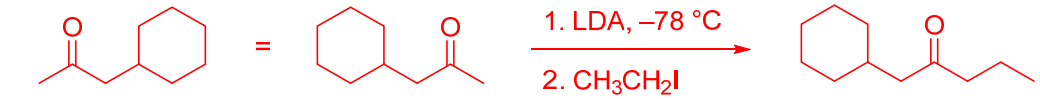
(3) (9 points)

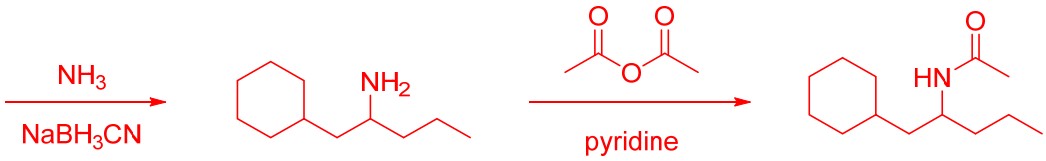


Problem IV. Synthesis (18 points). Design an efficient synthesis of compound **G** from the indicated starting materials and any other reagents you wish.



G





G