NAME:_____ Section: A Student Number:_____

Fall 2017 **Chemistry 4000 Midterm** ____/ 40 marks

INSTRUCTIONS:

1) Please read over the test carefully before beginning. You should have 6 pages of questions and a periodic table.
2) Unless otherwise stated in the question, explain all of your answers fully. Use diagrams where appropriate. When invoking any argument based on resonance, you must draw all relevant resonance structures.
3) ALL structures must be drawn showing lone pairs, non-zero formal charges and reasonable bond angles – regardless of whether they are expanded, condensed or line-bond. Marks will be deducted for poorly drawn structures.
4) Marks will be deducted for incorrect information added to an otherwise correct answer.
5) If your work is not legible, it will be given a mark of zero.
6) Calculators are not allowed. You are not permitted to have any electronic devices with you during the exam unless authorized by the instructor.
7) You may use a molecular model kit.
8) You have 2 hours to complete this test.

Confidentiality Agreement:

I agree not to discuss (or in any other way divulge) the contents of this exam until after 3:00pm Mountain Time on Thursday, November 2nd, 2017. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/40 on this exam; the maximum punishment would include expulsion from this university.

Signature: _____ Date: _____

Course: CHEM 4000A (Medicinal Chemistry)
Semester: Fall 2017
The University of Lethbridge

Question Breakdown

Q1	/ 5
Q2	/ 3
Q3	/ 4
Q4	/ 4
Q5	/ 6
Q6	/ 8
Q7	/ 10

Total	/ 40

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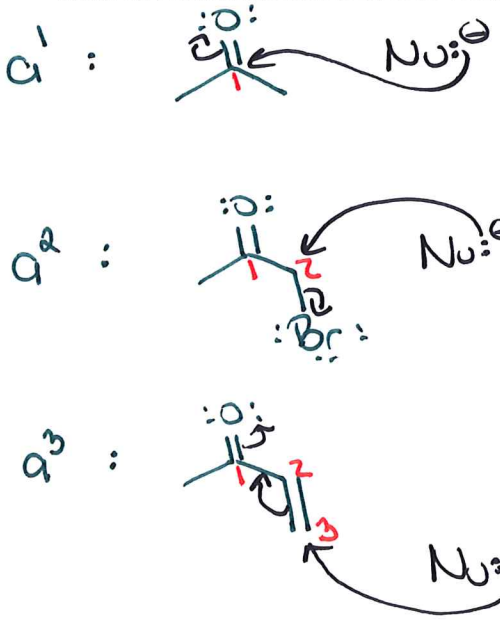
1. Consider the three main types of acceptor synthons: a^1, a^2 and a^3. **[5 marks]**

(a) Give an example of each of these types of synthons. Your example set should clearly illustrate what the numbers refer to and what an acceptor synthon is. *[3 marks]*



Count carbon atoms from the heteroatom to the electrophilic site to get the #

A synthon is only really acting as a natural a^3 synthon if the electrophilic site is connected to the C=O (or similar) via a π system.

(b) There is one more key difference between the a^2 synthon and the other two acceptor synthons listed above. What is this difference, and how might it affect choice of synthon? *[2 marks]*

a^1 and a^3 synthons are natural. An a^2 synthon is not. (It has umpoled reactivity.) This means that the a^1 and a^3 synthons take advantage of the inherent electrophilic nature of the carbonyl and are therefore easier to work with. When using an a^2 synthon, you may have to worry about a competing electrophilic site ∴ we prefer a^1 or a^3.

2. What is an auxiliary functional group? Give an example of a reaction for which an auxiliary functional group might be useful. What is the purpose of the auxiliary functional group in this particular reaction? **[3 marks]**

An auxiliary functional group is a functional group used to enhance the reactivity of a particular site but that does not appear in the target product ∴ must be removed.

eg If we wanted to make  (or an equivalent), we might use an auxiliary functional group:

After this enolate attacks the electrophile, the auxiliary $-CO_2Et$ group can be removed by heating with acid (decarboxylation)

Several students suggested protecting groups, but they don't reduce reactivity. They don't enhance it.

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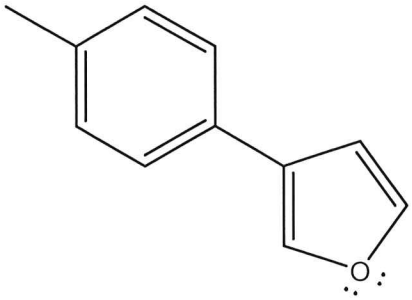
3. How could you use a Suzuki cross-coupling reaction to make the following molecule?

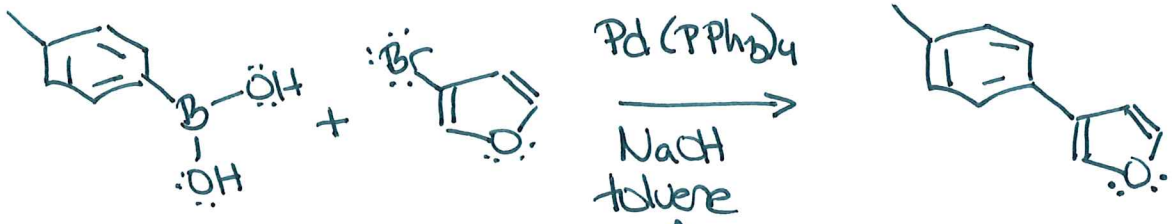
[4 marks]



Clearly identify all necessary reactants (organic and inorganic) and any relevant reaction conditions.

You do **not** need to show how your reactants would be prepared.

You do **not** need to draw a mechanism for this reaction.

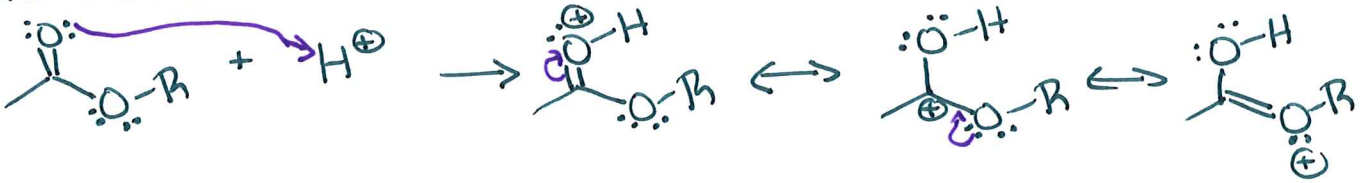


- can use other soluble Pd catalysts
- can use boronate ester instead of boronic acid
- can use iodide or triflate instead of bromide
- other options for base include NaOEt, KOtBu, carbonates

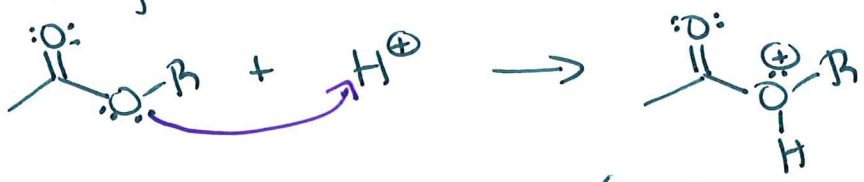
4. When we protonate an ester, we always protonate the carbonyl oxygen (=O) not the oxygen of the alkoxy group. Why?

[4 marks]

If we protonate the carbonyl oxygen, the positive charge is delocalized over three atoms:



If we protonate the oxygen of the alkoxy group, the positive charge is localized on a single atom:



(no resonance structures)

Since it is better to spread at charge, it is better to protonate the carbonyl oxygen.

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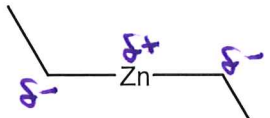
5. Diethylzinc (shown below) is a popular, if pyrophoric, source of nucleophilic carbon. **[6 marks]**



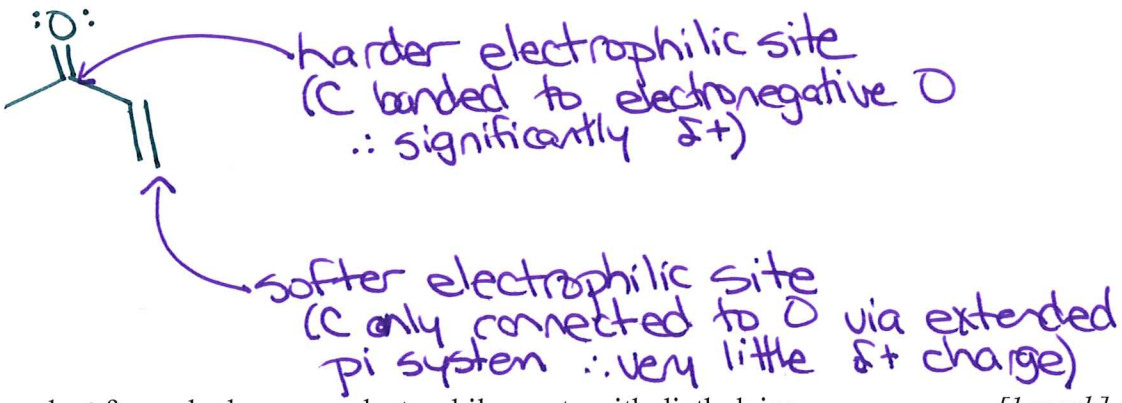
Since Zn is next to Cu on the periodic table, expect Et_2Zn to act a lot like cuprates

(a) Would you expect diethylzinc to be a hard nucleophile or a soft nucleophile? Explain. *[2 marks]*

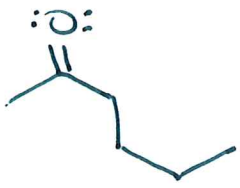
Et_2Zn is a soft nucleophile

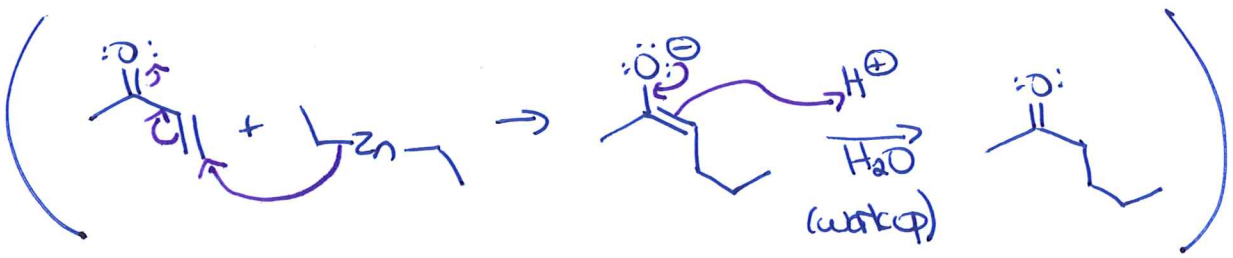
The electronegativity of Zn is not that much less than the electronegativity of C. Therefore, the charge density on C is low. Nucleophiles with low charge density on the nucleophilic atom(s) are soft. (size of Zn is irrelevant. Zn is not nucleophilic.)

(b) Draw an electrophile with a harder electrophilic site and a softer electrophilic site. Clearly identify the two sites and rationalize why one is harder/softer than the other. *[3 marks]*
Organic electrophiles only, please! ☺



(c) Draw the product formed when your electrophile reacts with diethylzinc. *[1 mark]*
*You do **not** need to include a mechanism for this reaction.*





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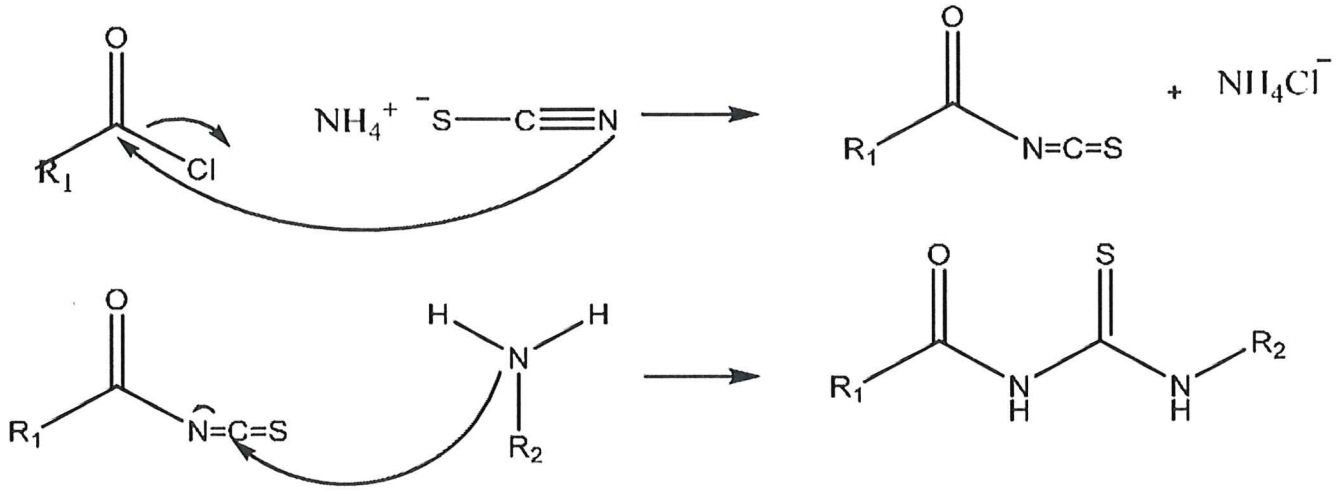
6. When I was putting together your Mechanistic Assignment, I came across the following "mechanisms" on somebody's ResearchGate page. They made me very sad. **[8 marks]**



(a) Identify three things that are wrong with these "mechanisms". Explain each. *[3 marks]*

The actual reactions are not problematic; the reactants and products are correct.

① The first step appears to be an S_N2 attack at a trigonal planar atom. That's not allowed!

② They should have either drawn the other resonance structure of $SCN^{\ominus}$ if started their arrows on $S^{\ominus}$ and started by creating an S=C double bond (see next page)

③ In the second reaction, protonation and deprotonation steps magically happen without electron pushing!

④ no lone pairs.

⑤ missing the ⊕ charge on $NH_4^{\oplus}$ ($NH_4Cl^{\ominus}$ is not a thing)

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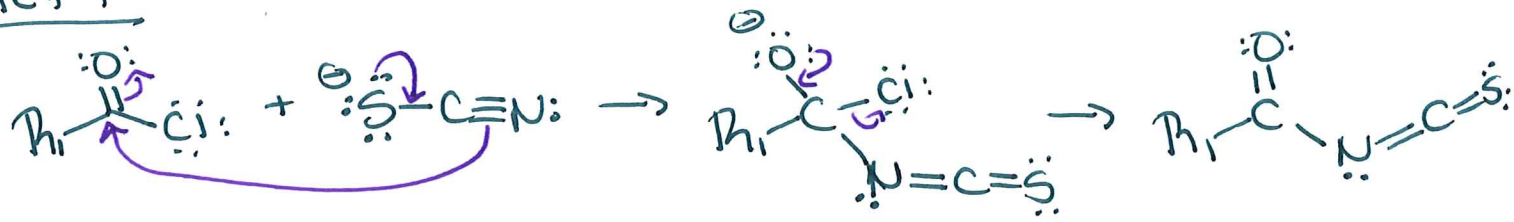
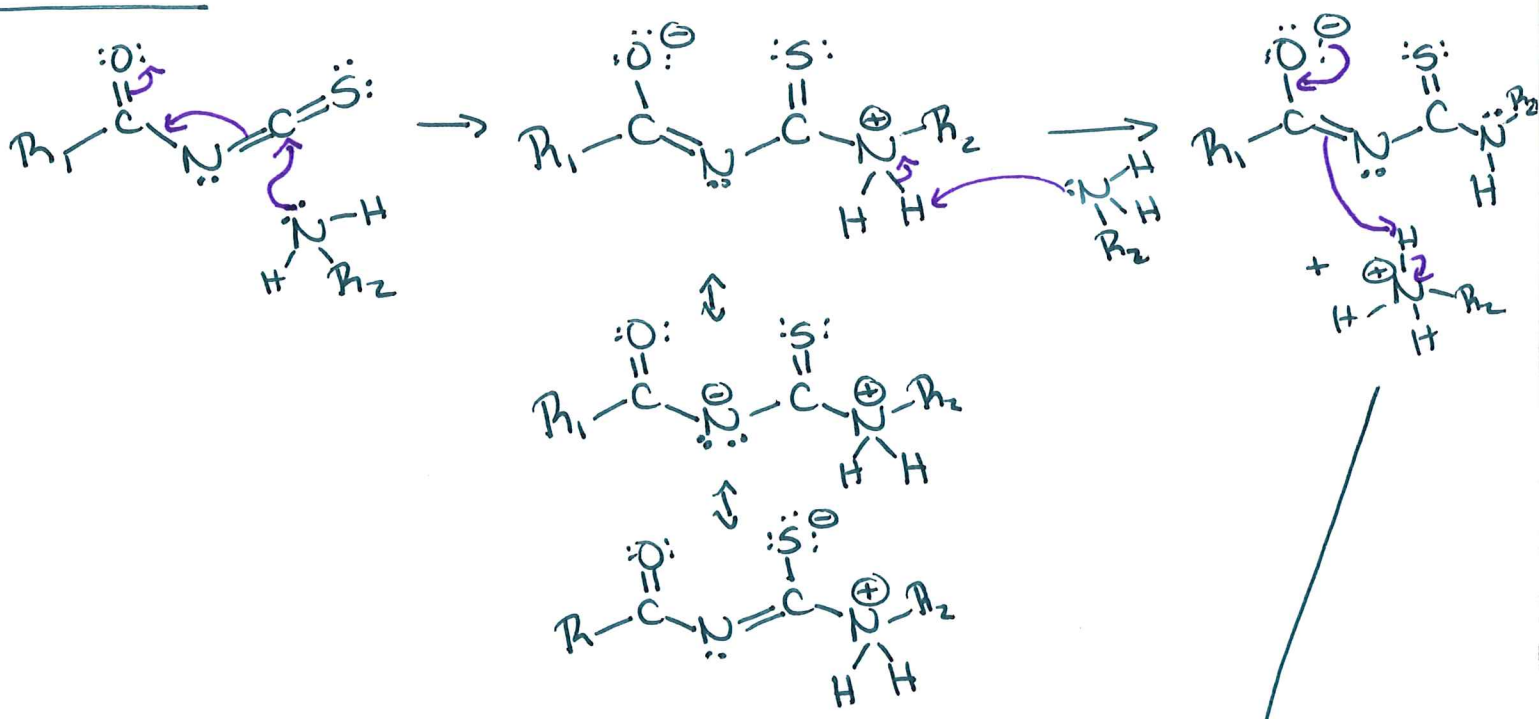
6. *continued...*

(b) Fix the mechanisms so that I don't have to be sad anymore! Draw a proper mechanism for each of these two reactions. You may assume excess R_2NH_2 for the second reaction. *[5 marks]*

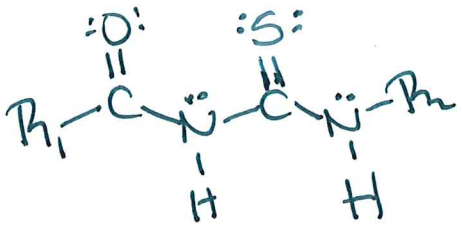
STEP 1



STEP 2



since ⊖ charge is delocalized over 3 atoms and amines are reasonably basic (but not very acidic) it makes sense to deprotonate $N^{\oplus}$ before protonating anion



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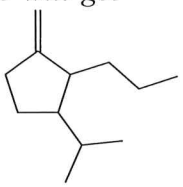
7. How would you make the molecule below? **[10 marks]**

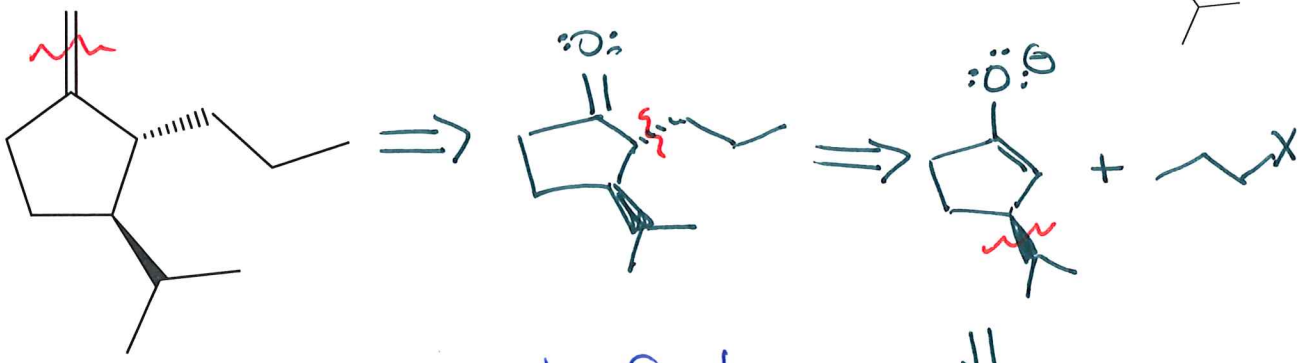
Your answer should take the form of a retrosynthetic analysis followed by chemical equations for the reactions in the synthesis itself. Write an equation for each reaction. Show all required reagents, and number steps within a reaction if order of addition is important.

You may use any reactants that you could reasonably expect to be commercially available and that contain no more than 6 carbon atoms. (Exception: Reagents may contain one or more benzene rings in addition to the 6 carbon limit.)

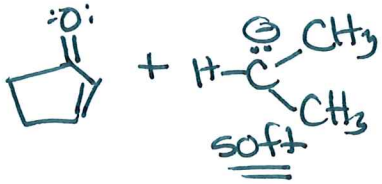
You do not need to control absolute stereochemistry; a synthesis of a racemic mixture will get full credit.

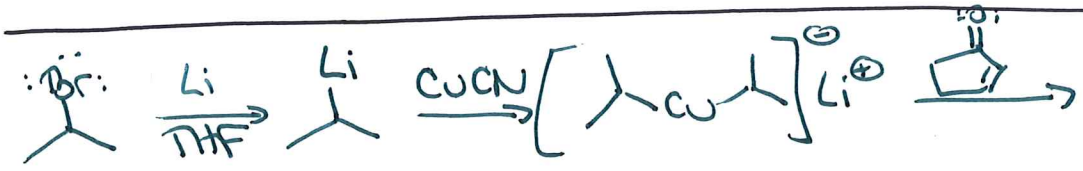
If you are not sure how to control the relative stereochemistry, propose a synthesis of





#It's much easier for me to find part marks if there's a clear retrosynthetic analysis#





don't work up! leave as enolate!

This isn't the only possible answer, but it's the simplest and combines a skeletal approach (attaching branches to a central ring) and a functional group approach (conjugate addition followed by enolate as nucleophile).