Spring 2023 **Chemistry 2500 Midterm #2** ____/60 marks

Confidentiality Agreement:
I agree not to discuss (or in any other way divulge) the contents of this exam until after 5:00pm Mountain Time on Friday, March 10th, 2023. I understand that breaking this agreement would constitute academic misconduct. The minimum penalty would be a mark of 0/60 on this exam.

Signature: _____ Date: _____

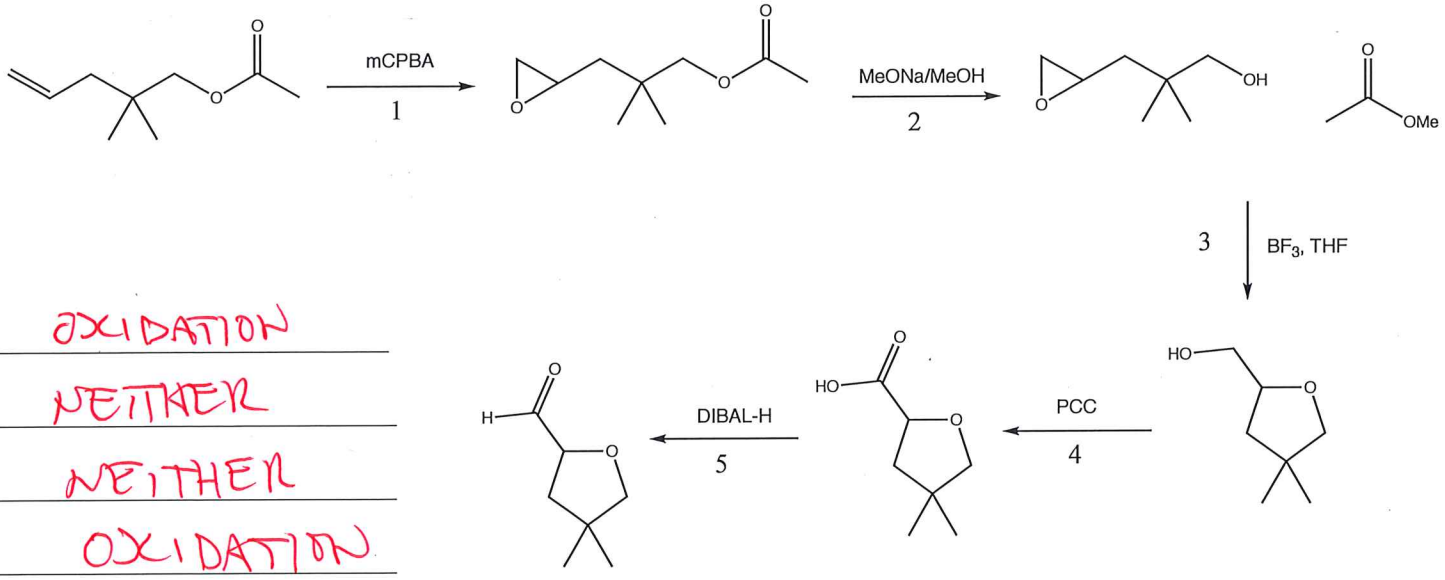


1) Please read the test carefully before starting. It has 10 pages of questions including a this cover page and two blank pages.
2) The exam is worth a total of 60 marks. Most of these marks are for explanation/showing your work rather than for reaching the correct answer. Explain all your answers fully using diagrams where appropriate (a picture really is worth a thousand words!).
3) You may use a molecular model kit and ruler. You may not have written materials in your model kit.
4) No calculators allowed.
5) **DO NOT WRITE ON ANY QR CODE!!!** Work on pages without a QR code will not be graded.
6) If your work is not legible, it will be given a mark of zero. For full credit, explanations must be complete. In many cases, complete explanations include drawing relevant structures.
7) Marks will be deducted for incorrect information added to an otherwise correct answer.
8) You have 2 hours to complete this test.

Question Breakdown

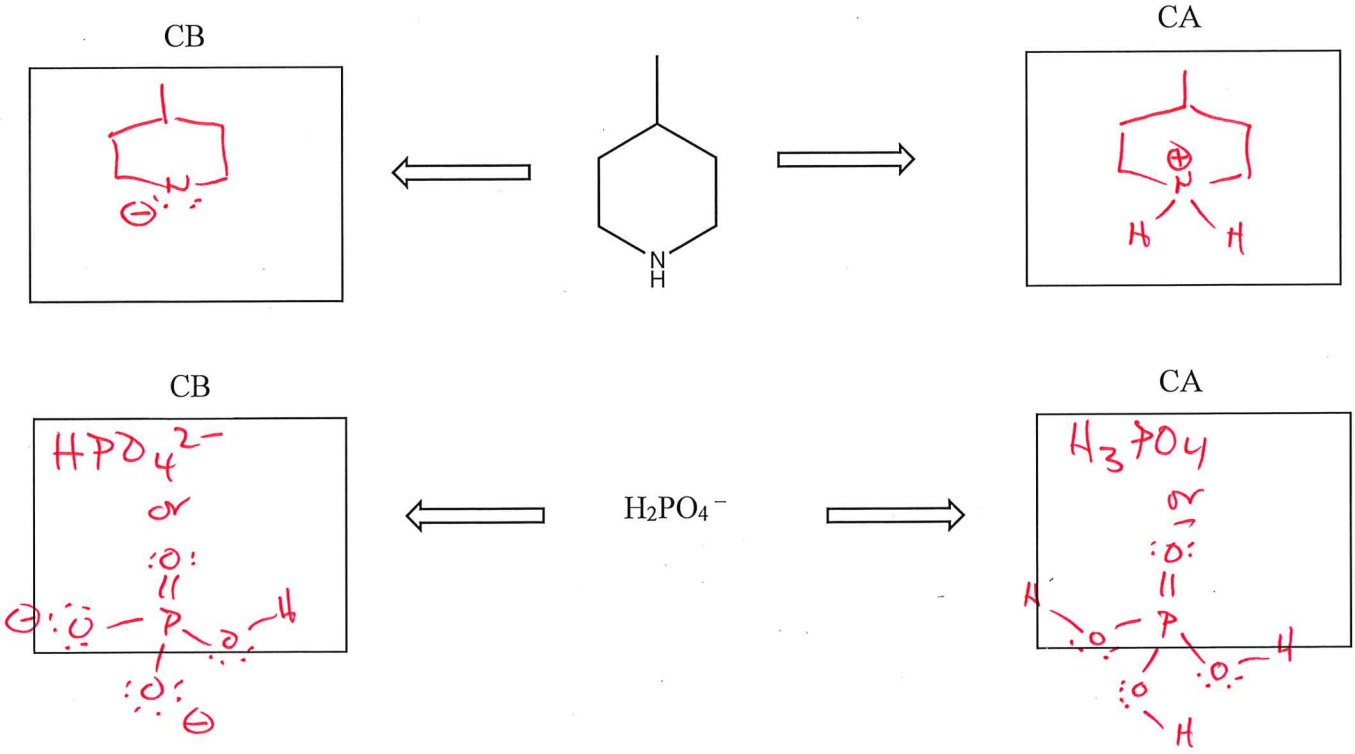
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10			Total		
/ 5	/ 4	/ 5	/ 6	/ 10	/ 8	/ 8	/ 4	/ 5	/ 5			/ 60		

1. For the following multistep sequence, label each reaction arrow in the space provided as an oxidation reaction, a reduction reaction, or neither. **[5 marks]**

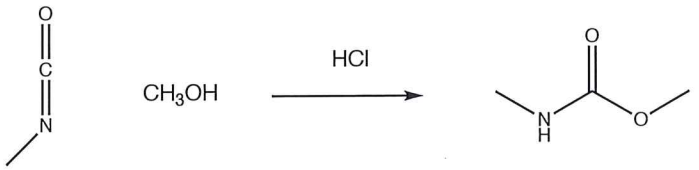


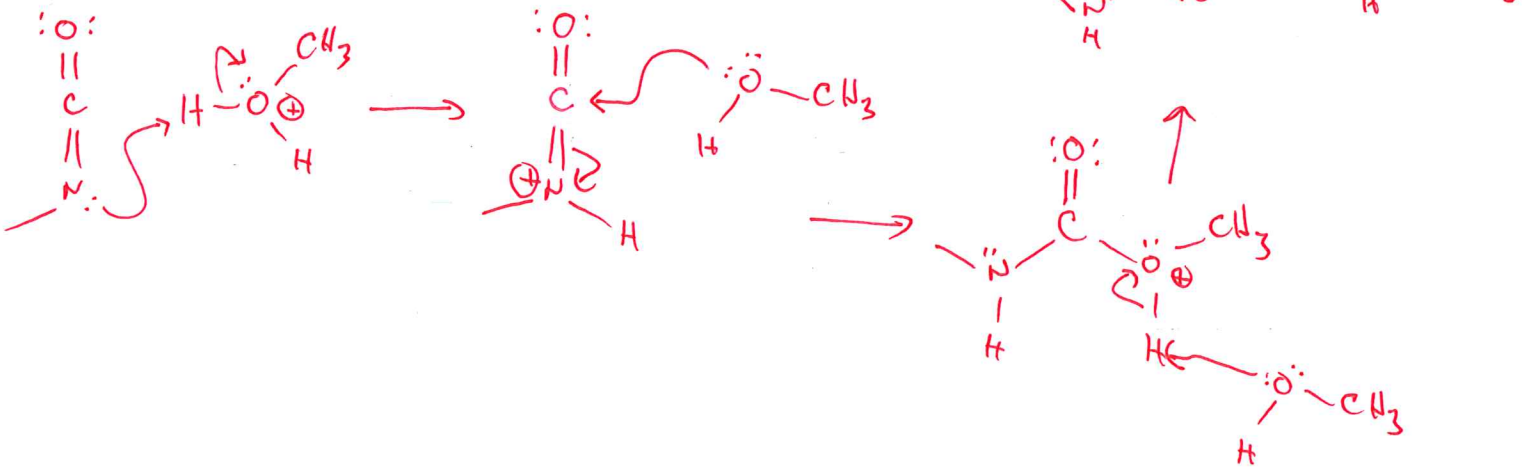
1. OXIDATION
2. NEITHER
3. NEITHER
4. OXIDATION
5. REDUCTION

2. For each of the following molecules, draw its conjugate base (CB) and conjugate acid (CA) in the appropriate box. **[4 marks]**



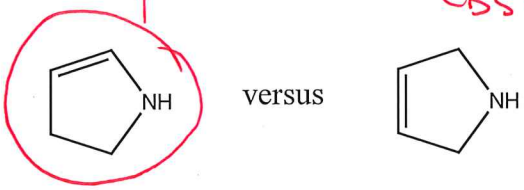
3. Propose a mechanism for the following reaction using curved arrows. Be sure to consider your reaction conditions. **[5 marks]**



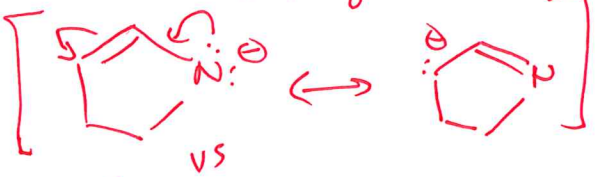


4. For each pair of molecules, identify the strongest acid and briefly explain your choice. **[6 marks]**

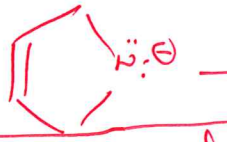
(a)



conjugate is resonance stabilized.

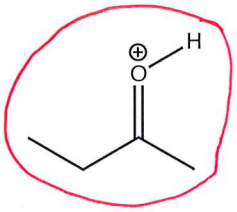
CBs: 

vs

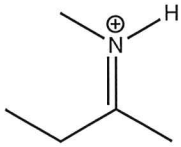


→ no resonance.

(b)



versus



acids are charged so look at acids, not CBs.
→ compare O⊕ vs N⊕. Since they are in the same period look at electronegativity. O is more electronegative than N and ∴ it is less stable with ⊕ charge which makes it more acidic.

(c)

CH_4 versus SiH_4

CBs: $H_3C:^{\ominus}$ vs $H_3Si:^{\ominus}$

Both C & Si are in the same group therefore look at atom size. Si is larger than C and ∴ can spread the ⊖ charge better making the CB more stable (weaker) ∴ its acid is stronger.

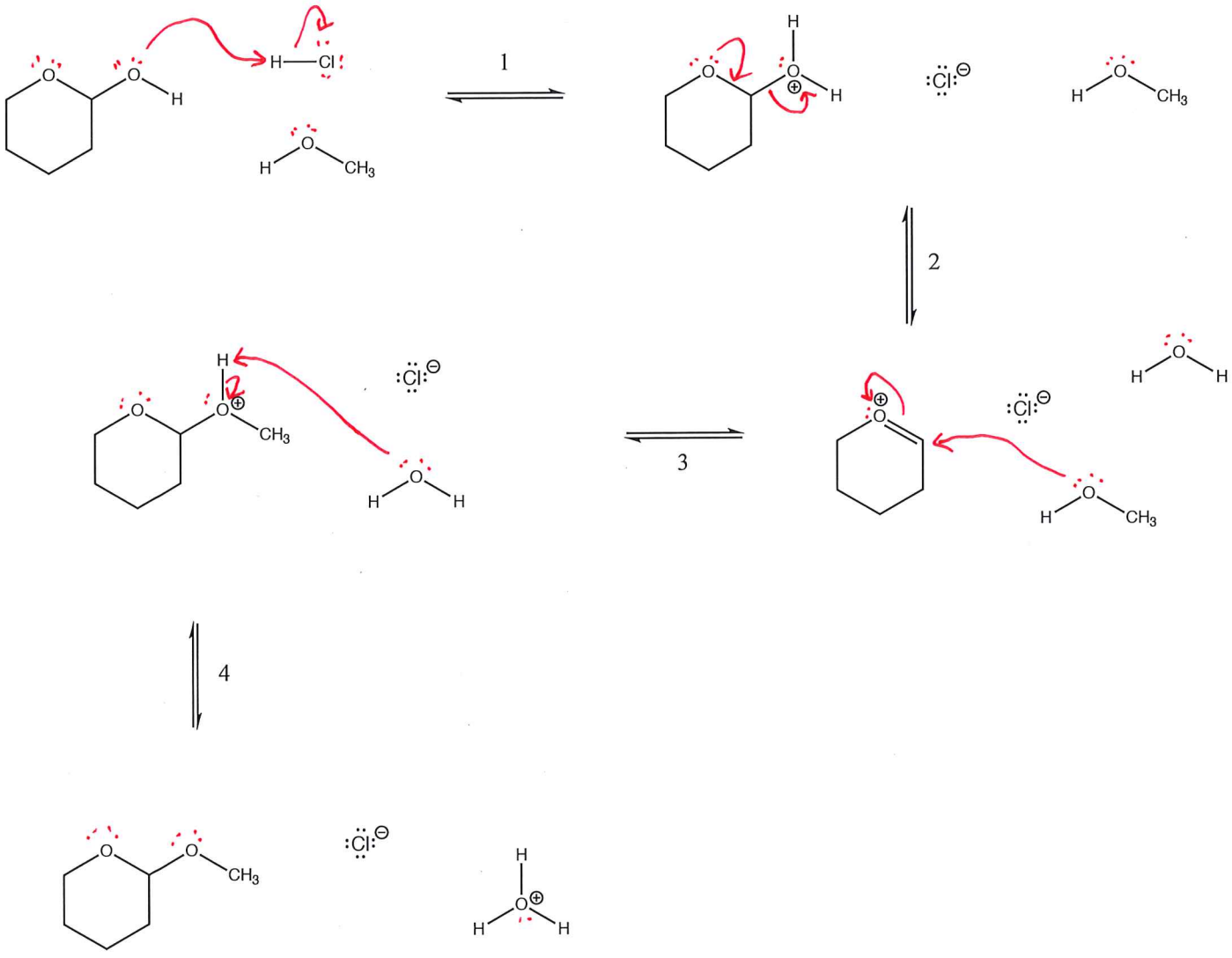
5. Consider the following reaction: **[10 marks]**

(i) Include all missing lone pair electrons.

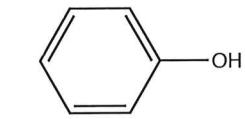
(ii) For steps 1-4, add mechanistic arrows to show the flow of electrons.

(iii) For each step (1-4), identify which type of reaction is occurring (proton transfer, nucleophilic attack, or leaving group loss):

- Step 1: Proton transfer
- Step 2: leaving group loss
- Step 3: nucleophilic attack
- Step 4: proton transfer

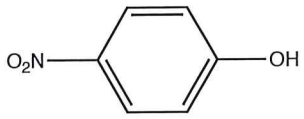


6. Consider the molecules phenol and 4-nitrophenol and their respective pKa values. Explain why 4-nitrophenol is a 1000 times more acidic than phenol. **HINT** Start by drawing the conjugate base of each molecule. A picture is worth a thousand words!! If your answer refers to a structure, a resonance form, a reaction, etc., DRAW it! Do not just use words to describe these. An entire language has been developed to represent these species with pictures and we are partly testing you on your ability to use this language. **[8 marks]**



$pK_a = 10$

Note how a nitro group is drawn

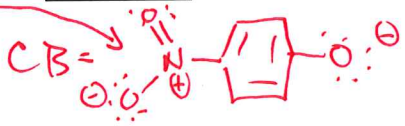


$pK_a = 7$

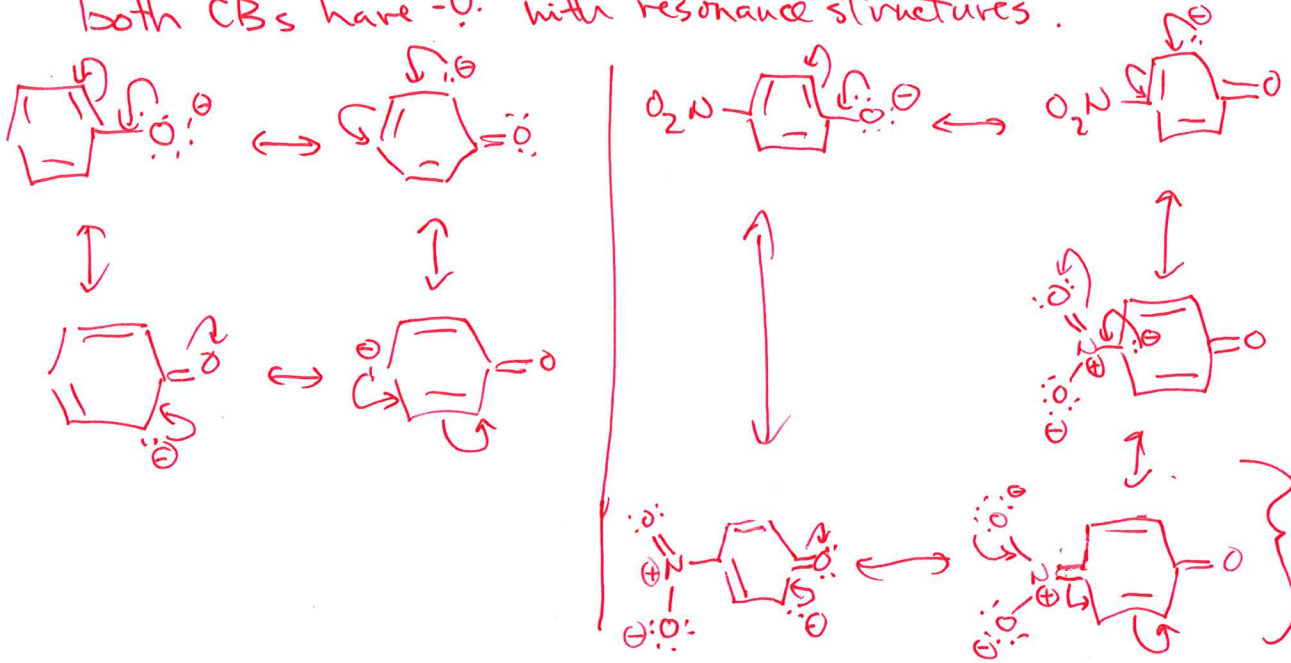
CB =



CB =



both CBs have $-\ddot{O}:^{\ominus}$ with resonance structures.



While both of the CBs are resonance stabilized, the CB of 4-nitrophenol has more resonance stabilization which makes the CB weaker (more stable) and therefore its acid stronger.

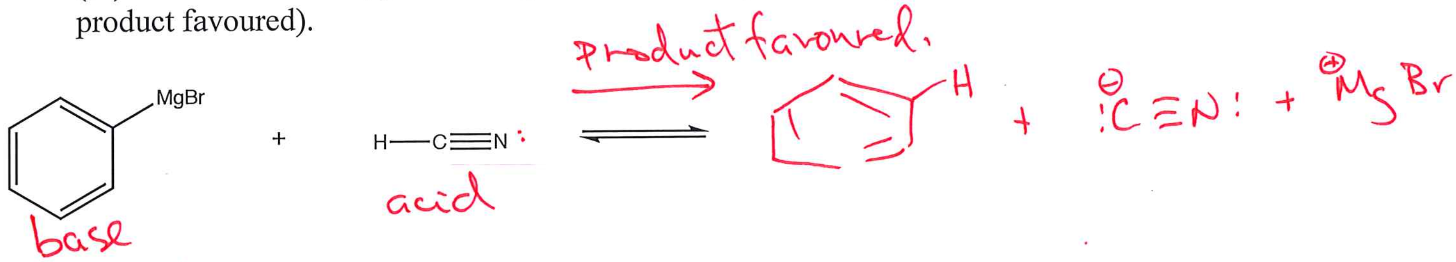
∴ 4-nitrophenol is the stronger acid.

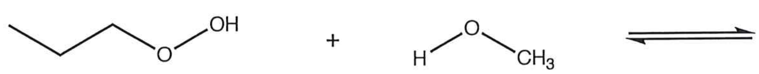
7. For each of the following reactions: **[8 marks]**

(i) Add all missing lone pair electrons and identify the acid and base.

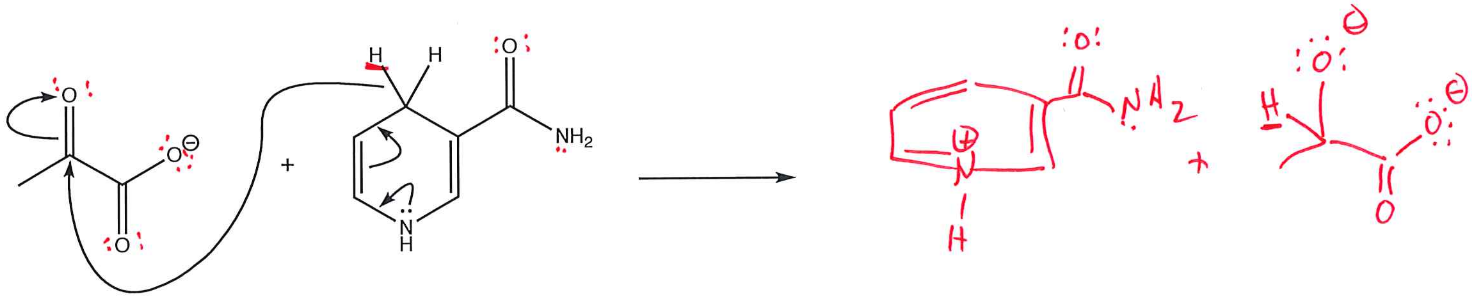
(ii) Draw the product(s) of each reaction in line-bond notation. Be sure to include all lone pairs and formal charges.

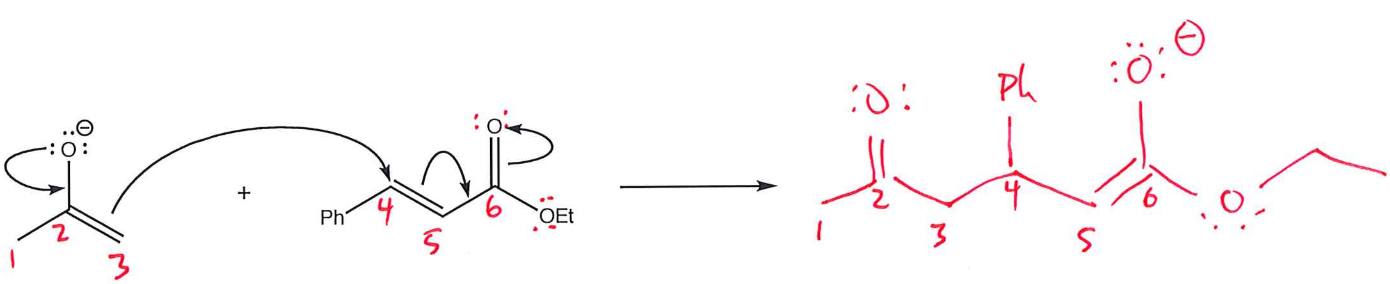
(iii) For each reaction, predict the position of the equilibrium (indicate whether the reaction is reactant or product favoured).





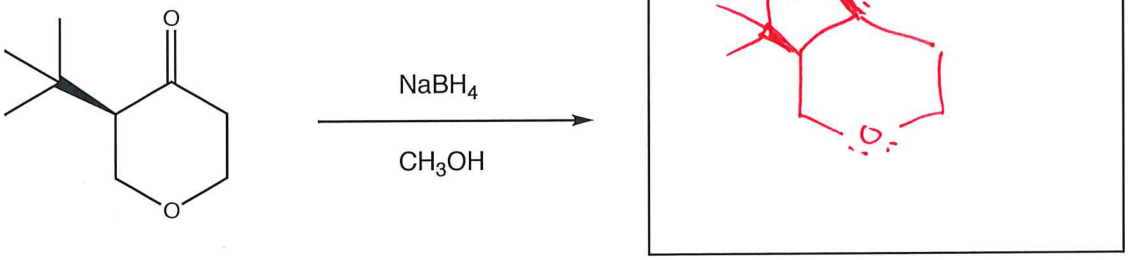
8. For each of the following reactions, use the mechanistic arrows provided to draw the product or products in line-bond notation. Include all lone pair electrons and formal charges. **[4 marks]**



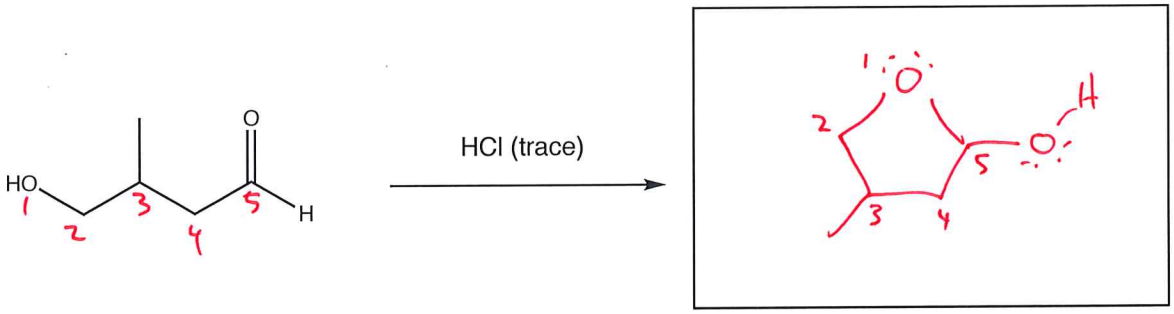


9. For each of the following reactions, provide the missing starting material(s) or product(s). If more than one product is formed, only draw the major one. Indicate stereochemistry where appropriate. **[5 marks]**

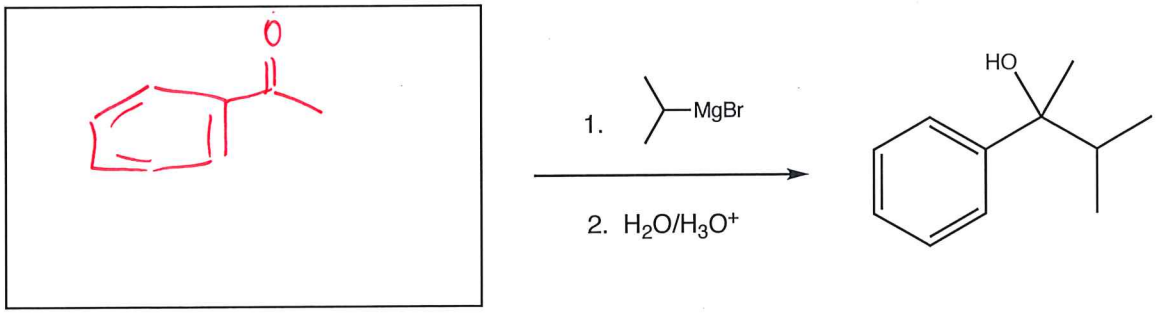
(a)



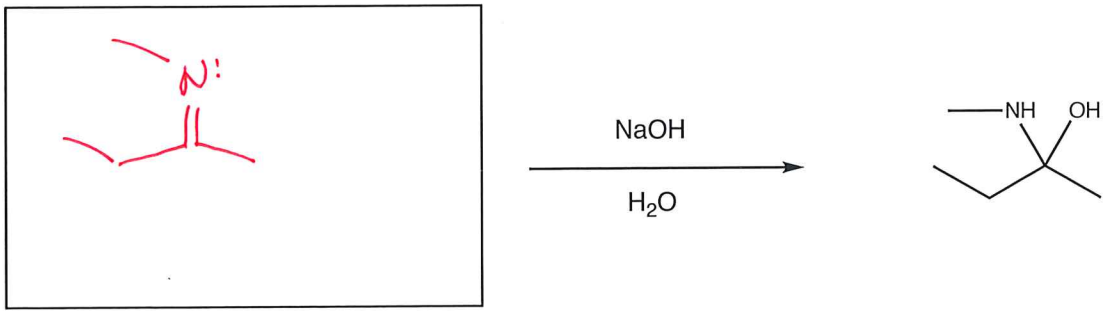
(b)



(c)

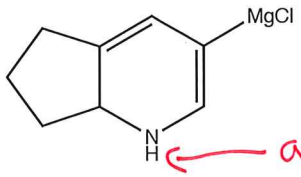


(d)



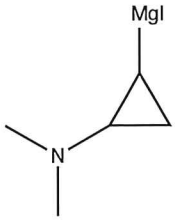
10. (i)For each of the following Grignard reagents, indicate whether the formation of the Grignard reagent would be successful (yes or no). **[5 marks]**

(a)



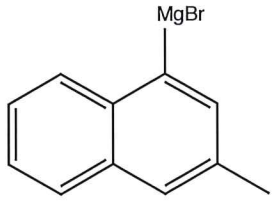
NO ← acidic proton

(b)



YES

(c)



YES

(ii) For any one Grignard reagent that you answered yes to in part (i), draw the reaction of how you would prepare this Grigard reagent. Your answer should be a reaction equation including all essential information.

ONE OF:

