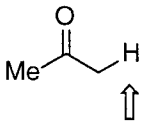
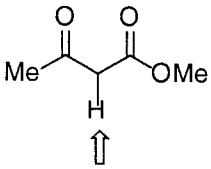
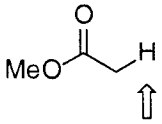
(1) (2 points each, 12 points total) In the boxes, please provide the requested data.

(a) pK_a of:  20

(b) pK_a of:  11

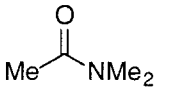
(c) pK_a of:  25

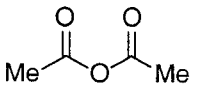
(d) pK_a of: $Me_3NH^{\oplus}$ $Cl^{\ominus}$ 9-11

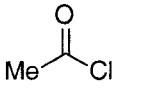
(e) pK_a of: Me_2NH 35

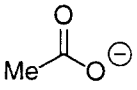
(f) pK_a of: EtOH 16

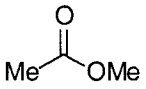
(2) (5 points, all or nothing) In the boxes, please rank the five acyl derivatives for their reactivity as electrophiles toward hydroxide ion (1 = most reactive, 5 = least reactive).

 4

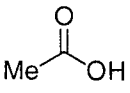
 2

 1

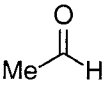
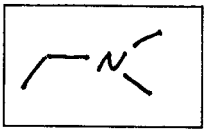
 5

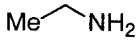
 3

(3) (2 points each, 20 points total) In the boxes, please provide the requested reagent(s) or product(s). If no reaction is expected, write "NR".

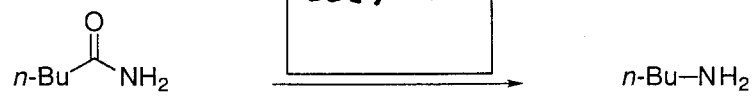
(a)  excess MeMgBr → workup → N.R

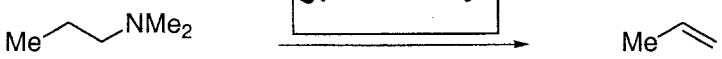
2 pts each

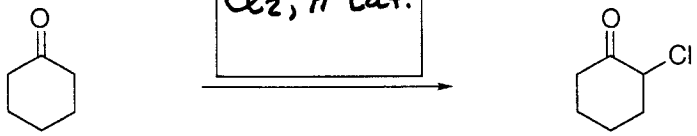
(b)  $HNMe_2$ $\xrightarrow[\text{acid catalyst}]{NaBH_3CN}$ 

(c) Me–CN $\xrightarrow{\text{LAH}}$ 

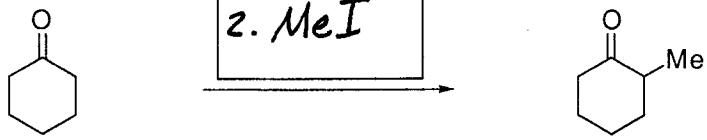
(3) (continued)

(d) 

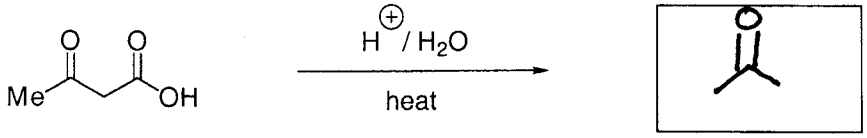
(e) 

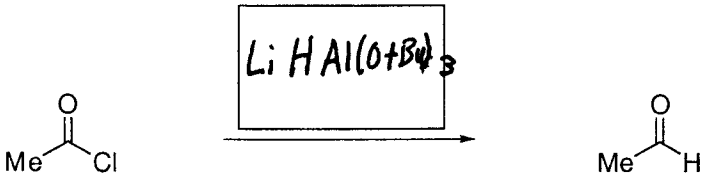
(f) 

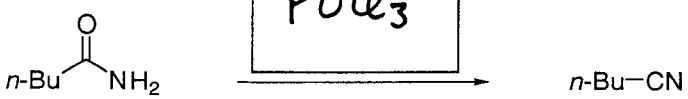
WITHOUT over-chlorination

(g) 

WITHOUT over-alkylation

(h) 

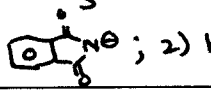
(i) 

(j) 

(4) (4 points each, 8 points total) In the boxes, please provide reagents for the illustrated transformations. More than one step may be required.

4 pts

(a) Me–Br → Me–NH_2

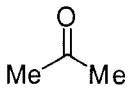
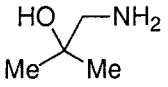
method 1: excess NH_3 (not favorable)
" 2: 1) NaN_3 ; 2) LAH
" 3: 1)  ; 2) H_2NNH_2

WITHOUT over-alkylation

−2 if in one step when should be 2 steps (for both)

−1 if $H^{\oplus}$ cat HCN

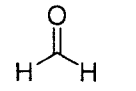
4 pts

(a)  → 

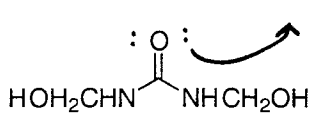
1) HCN, $^{\ominus}OH$ cat ↑ok if forgot.
2) LAH

−2 if 2nd step wrong

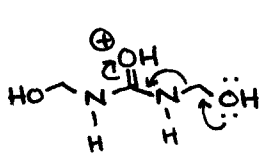
(5) (7 points) Formaldehyde is an effective preservative, but it has some undesirable properties–it is a strong irritant and has an unpleasant odor. In order to use formaldehyde in cosmetics, the compound dimethylolurea was synthesized. This compound slowly releases traces of formaldehyde under the mildly acidic conditions of the skin. Propose a mechanism for the release of formaldehyde from dimethylolurea under these conditions.



formaldehyde



dimethylolurea



−1 if ⊖ in acid conditions

−1 if put steps together

−1 if 2 ⊕ in mol.

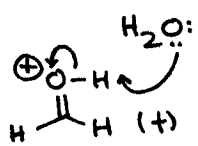
−2 if protonate N & not O in step 1

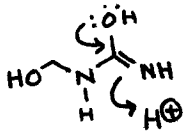
+4 if do 4 mem ring mech. & get rest of ans. ok.

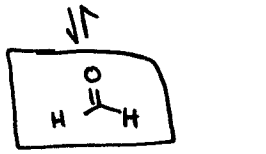
+2 if acyl transfer like mech getting to

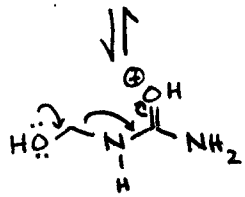
+1 if 1st stp of O protonation

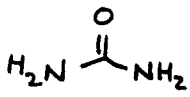
+1 if have $\nearrow C\equiv O^{\oplus}$ in mech.

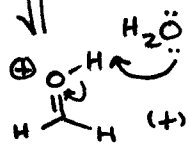


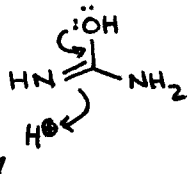


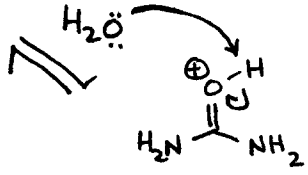




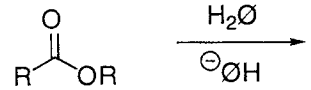






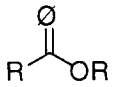


(6) (12 points total) In class, we discussed the hydrolysis of an ester under basic conditions with ^{18}O-labeled hydroxide and water. Experimentally, what is observed is illustrated below.

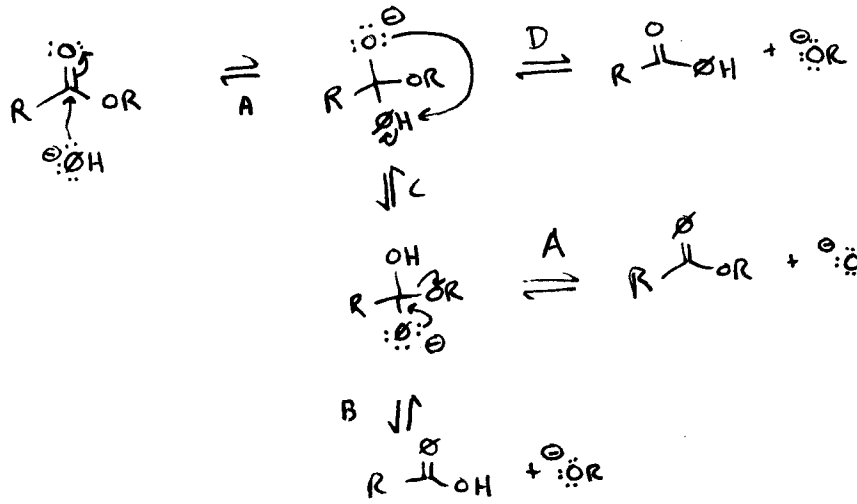


stop the reaction at 50% conversion

observation: the recovered ester contains a significant amount of:



(a) (7 points) With the aid of the mechanism for base-mediated ester hydrolysis, carefully explain why some of the "unreacted" (i.e., non-hydrolyzed) ester has Ø in the carbonyl oxygen.



Rate of proton transfer: 1

Mechanism: 3

Leaving groups + rates: 3

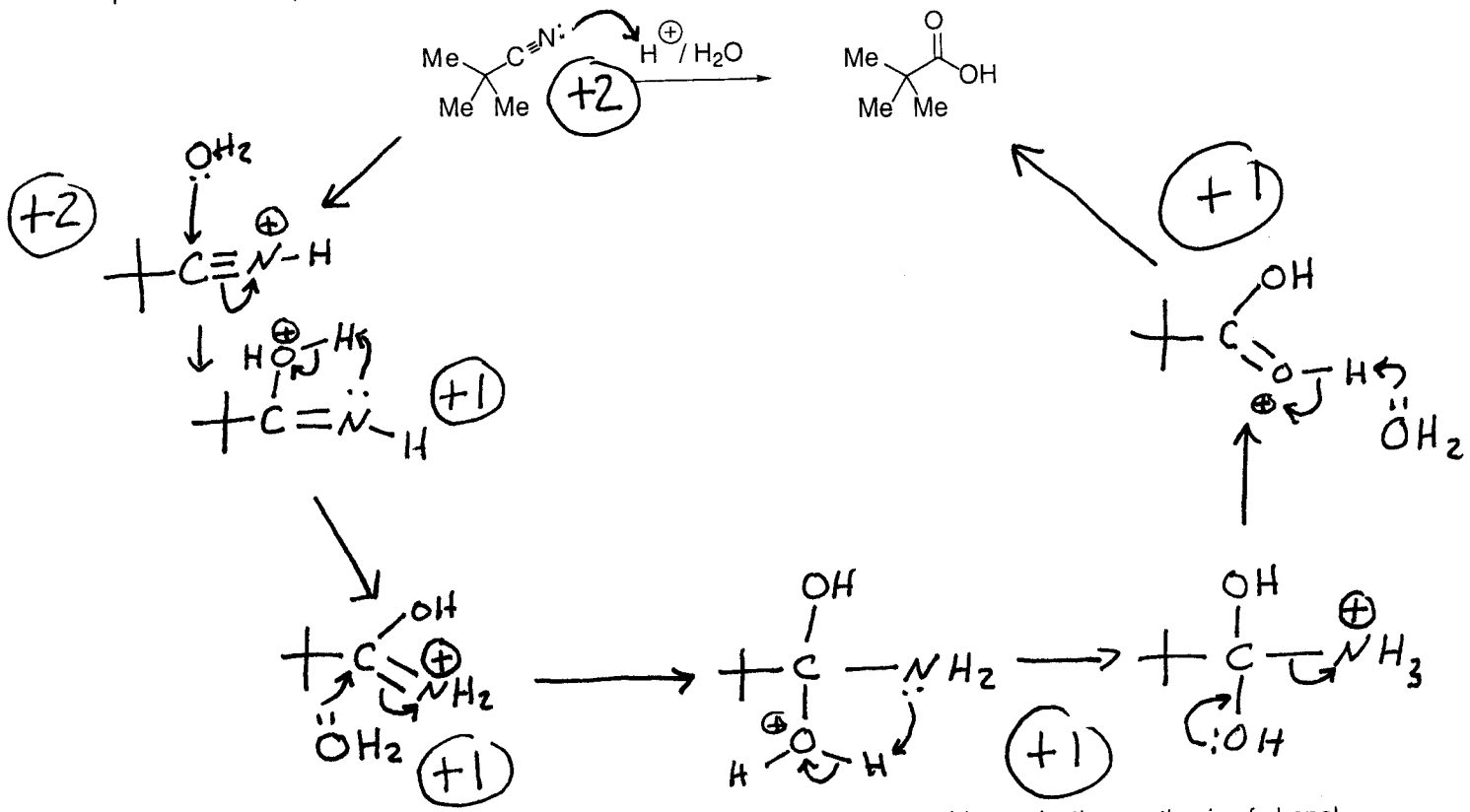
If $^{\ominus}\ddot{O}H$ and $^{\ominus}\ddot{O}R$ have similar leaving-group properties, A and B will occur at comparable rates. Since C is fast relative to D, a significant amount of A is recovered with Ø in the carbonyl oxygen.

(b) (5 points) Assume that the alkoxide is a poorer leaving group than hydroxide. Compared to the situation in which they have identical leaving-group ability, would this situation (alkoxide being a poorer leaving group than hydroxide) lead to **more** Ø incorporation or **less** Ø incorporation in the carbonyl group of the ester? Please clearly explain your reasoning.

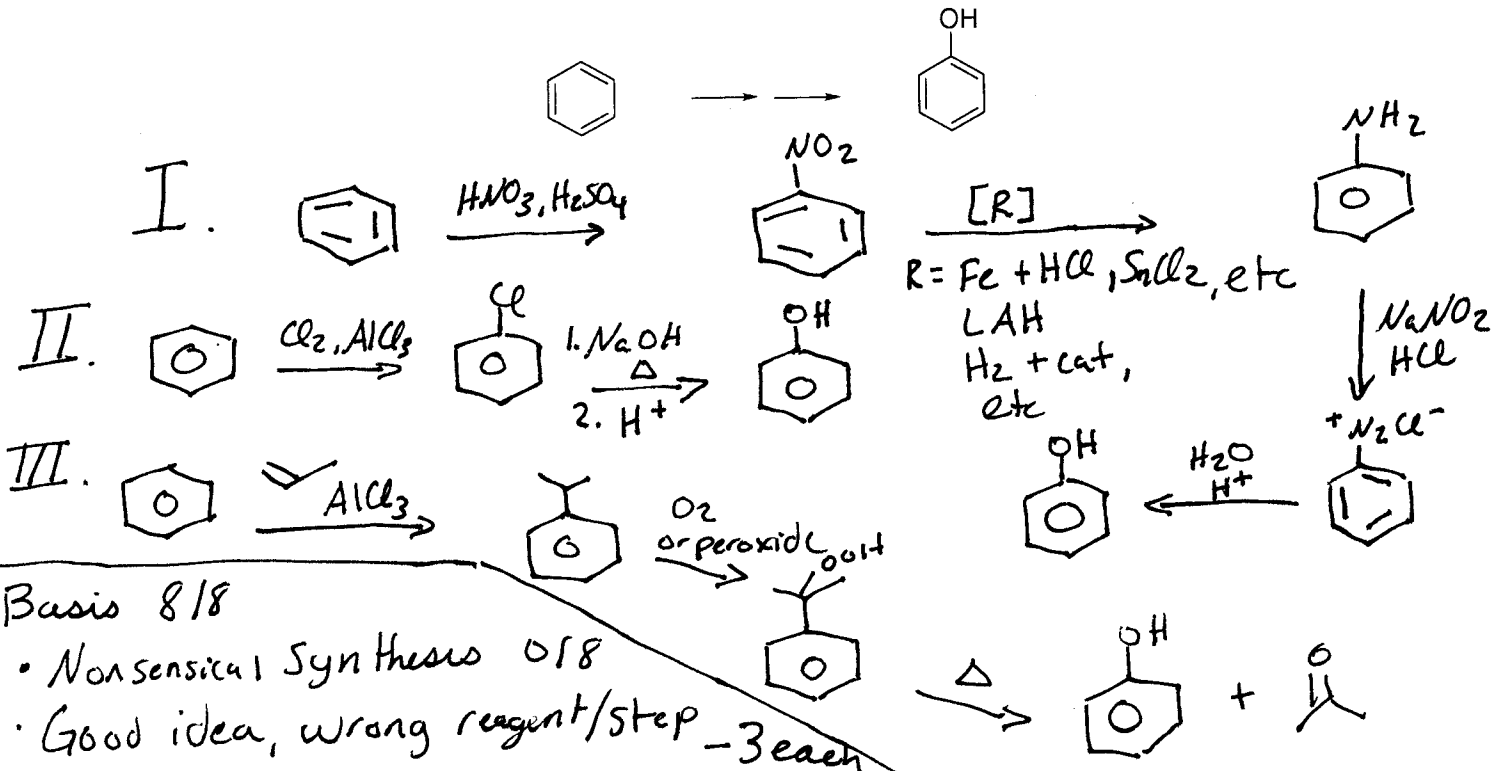
If $^{\ominus}OR$ is a poorer leaving group than $^{\ominus}OH$, more labelled ester would be recovered because A would be faster than B.

Answer more w/o explanation = 2 pts.

(7) (8 points) Provide the best mechanism for the illustrated tranformation. Please show all steps (including proton transfers) and all arrow pushing.



(8) (8 points) With chemistry that we have discussed in class, please provide a selective synthesis of phenol from benzene. More than one step is required.



Basis 8/8

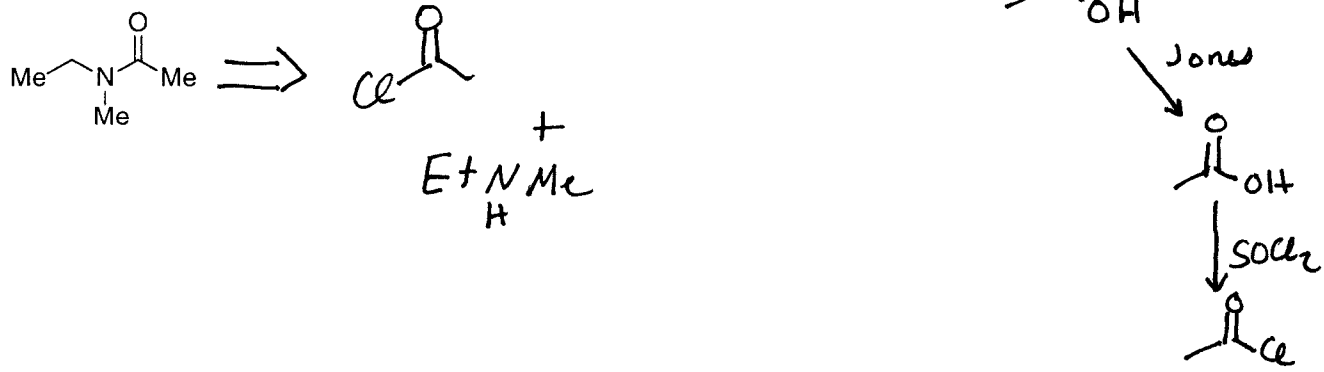
- Nonsensical Synthesis 0/8
- Good idea, wrong reagent/step -3 each

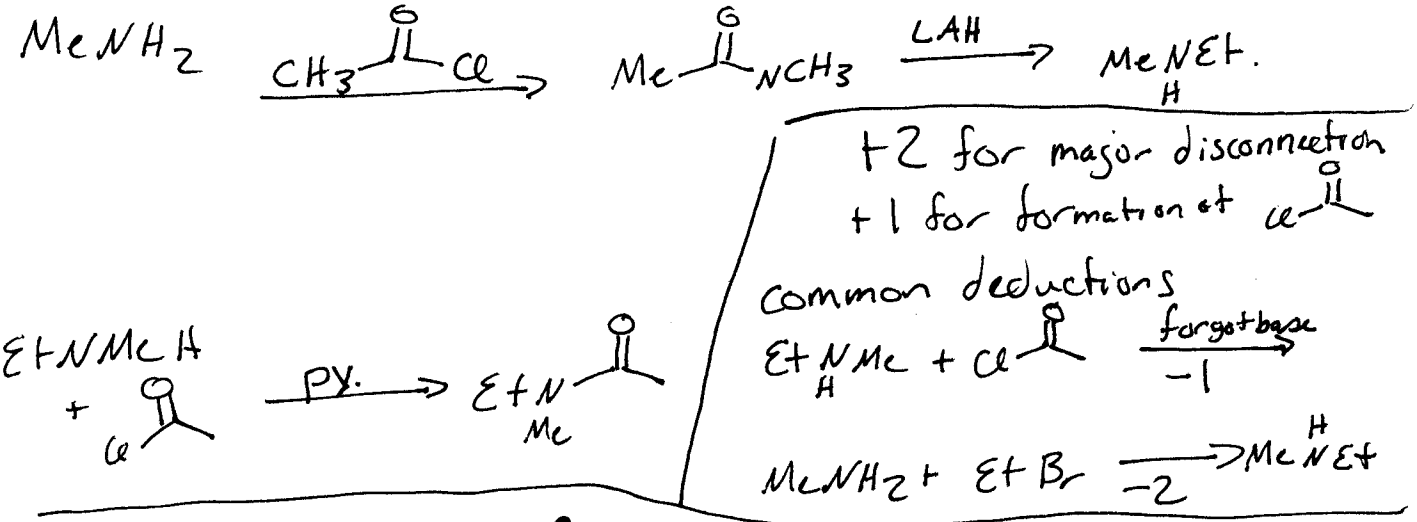
$NaNO_2$ vs HNO_2 -1

No H_2O or no acid in last step

(9) (10 points each, 20 points total) Please selectively synthesize the compounds illustrated below. All of the carbons of the products should come from EtOH and compounds that contain just one carbon.

(a)





(b)