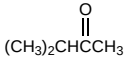
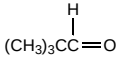
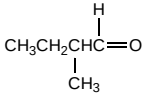
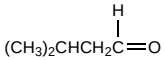
Name: _____ Last four numbers of the ID: _____

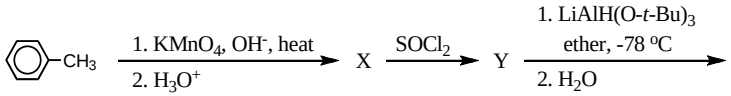
Part A

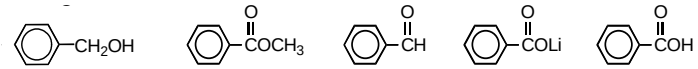
1. The IR spectrum of which type of compound will not show evidence of hydrogen bonding?
   A) Aldehyde
   B) Alcohol
   C) Carboxylic acid
   D) Phenol
   E) Primary amine

2. $LiAlH_4$ (LAH) cannot be used to convert carboxylic acids to the corresponding aldehydes because:
   A) LAH is not sufficiently reactive.
   B) RCOOH is converted into RCOOLi.
   C) LAH is too reactive and RCOOH is reduced to RCH_2OH.
   D) RCOOH is reduced to RCH_3.
   E) RCOOH is converted into $R_2C{=}O$.

3. A compound with formula $C_5H_{10}O$ gives two signals only, <u>both singlets</u>, in the ^1H NMR spectrum. Which of these structures is a possible one for this compound?
   A)
   B) 
   C) 
   D) 
   E) 

4. What is the final product, Z, of the following synthesis?



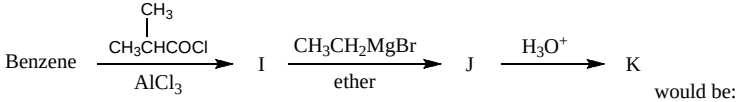


I II III IV V

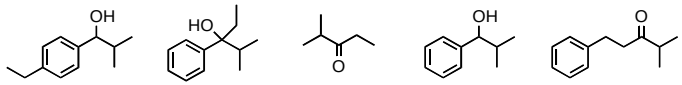
A) I
B) II
C) III
D) IV
E) V

5. An aldehyde results from the reaction of which of these compounds with aqueous base?
   A) $CH_3CH_2CH_2Cl$
   B) $CH_3CHClCH_2Cl$
   C) $CH_3CH{=}CCl_2$
   D) $CH_3CH_2CHCl_2$
   E) $CH_3CCl_2CH_3$

6. The product, K, of the following sequence of reactions



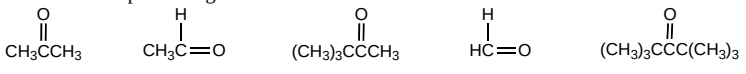
would be:



I II III IV V

A) I
B) II
C) III
D) IV
E) V

7. What, in general, is the order of decreasing reactivity of these carbonyl compounds towards nucleophilic reagents?

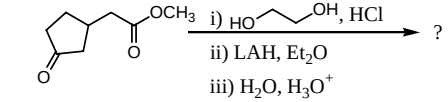


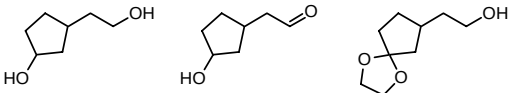
I II III IV V

A) I > III > V > II > IV
B) IV > II > I > III > V
C) V > III > I > II > IV
D) II > I > V > III > IV
E) III > V > IV > II > I

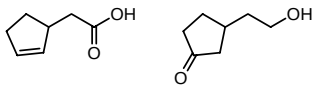
8. The compound C_6H_5-CH=N-NH_2 is produced by the reaction of benzaldehyde with which compound?
A) Ammonia
B) Hydrazine
C) Nitrogen
D) Phenylhydrazine
E) Hydroxylamine

9. What is the major product of the following reaction sequence?





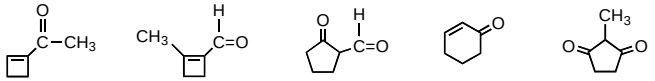
I II III



IV V

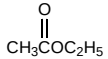
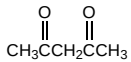
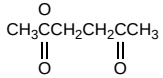
A) I
B) II
C) III
D) IV
E) V

10. The aldol cyclization of  produces which of these?

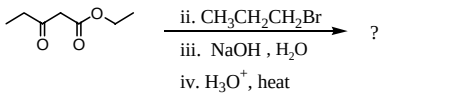


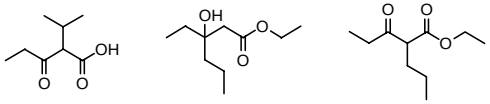
I II III IV V

A) I
B) II
C) III
D) IV
E) V

11. Which of these compounds would have the lowest pKa?
A) 
B) 
C) 
D) 
E) 

12. Predict the product of the following reaction sequence.

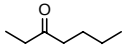




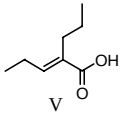
I

II

III



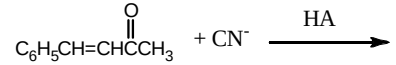
IV

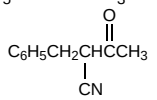


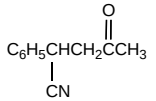
V

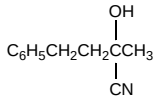
A) I
B) II
C) III
D) IV
E) V

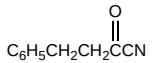
13. What would be the major product of the following reaction?

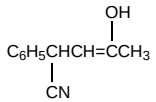


A)


B)


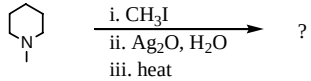
C)


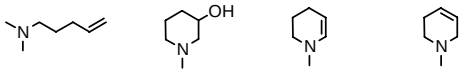
D)


E)


14. What final product is expected when toluene ($C_6H_5CH_3$) is subjected to the following reaction sequence?
i) $KMnO_4$, NaOH;
ii) H_3O^+ (product = $C_7H_6O_2$);
iii) $SOCl_2$;
iv) NH_3 (product = C_7H_7NO);
v) Br_2, NaOH
A) $C_6H_5CONH_2$
B) $C_6H_5CH_2NH_2$
C) p-$CH_3C_6H_4SO_2NH_2$
D) p-$CH_3C_6H_4NH_2$
E) $C_6H_5NH_2$

15. What would be the product of the following reaction sequence?



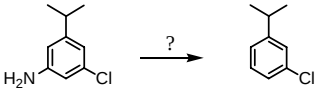


I II III IV

A) I
B) II
C) III
D) IV
E) I and II only

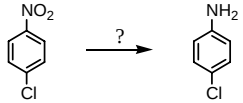
16. When an equimolar mixture of ammonia and butyl bromide reacts, which of these products will form?
A) Butylamine
B) Dibutylamine
C) Tributylamine
D) Tetrabutylammonium bromide
E) All of these

17. How would one carry out the following transformation: ?



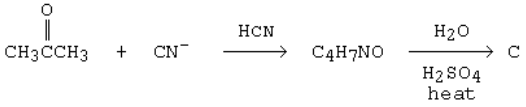
A) $NaNO_2$,HCl, 0-5°C; then HNO_3
B) $NaNO_2$,HCl, 0-5°C; then H_3PO_2
C) $NaNO_2$,HCl, 0-5°C; then H_2,Ni
D) $C_6H_5SO_2Cl$, OH^-; then HCl
E) NaH, DMSO

18. What reagent can effect the following transformation?

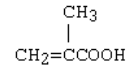


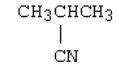
A) Sn + HCl; then OH^-
B) NH_2Cl
C) H_3PO_2
D) CuCN
E) HONO, then NH_3

19. The product, C, of the following reaction sequence,



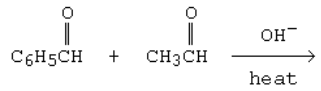
would be:

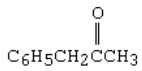
A) 

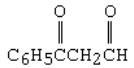
B) $CH_3CH_2COOCH_3$
C) 

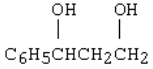
D) $CH_3CH=CHCOOH$
E) None of these

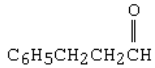
20. What would be the major product of the following reaction?

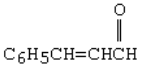


A) 

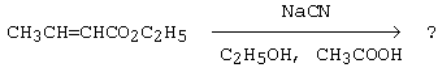
B) 

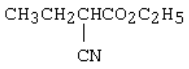
C) 

D) 

E) 

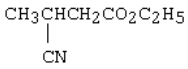
21. What would be the product of the following reaction?

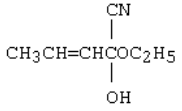


A) 

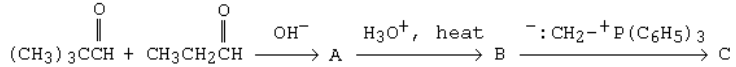
B) $CH_3CH{=}CHCO_2CN$

C) $CH_3CH{=}CHCN$

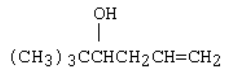
D) 

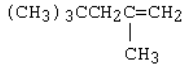
E) 

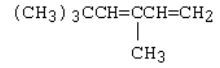
22. What would be the product, C, of the following reaction sequence?

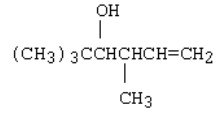


A) $(CH_3)_3CCH_2CH_2CH_2OH$

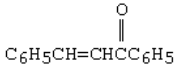
B) 

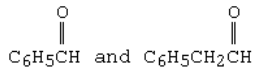
C) 

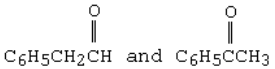
D) 

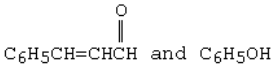
E) 

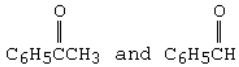
23. Which reagents would you use to synthesize this compound by an aldol condensation?

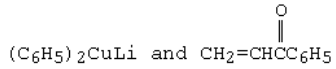


A) 

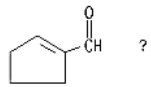
B) 

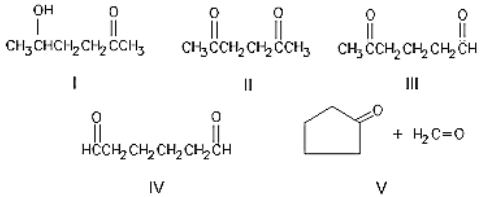
C) 

D) 

E) 

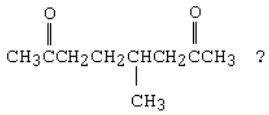
24. What starting compound(s) would you use in an aldol reaction to prepare

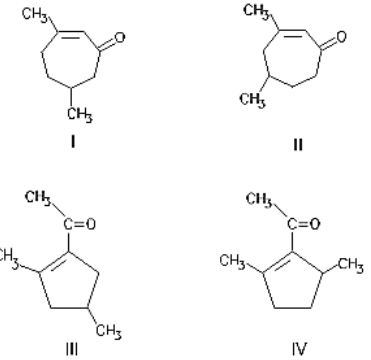




A) I
B) II
C) III
D) IV
E) V

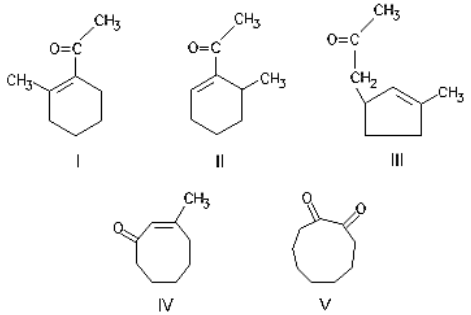
25. What compound results from the aldol cyclization of





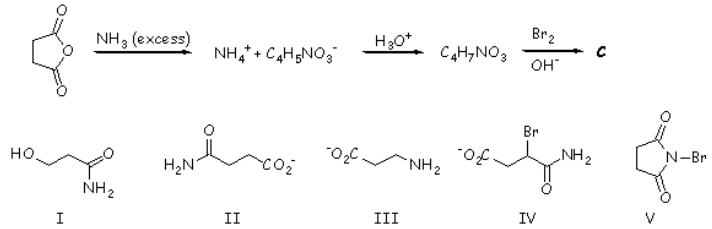
A) I
B) II
C) III
D) IV
E) Both III and IV

26. When  cyclizes in basic solution, which of these compounds will be formed?



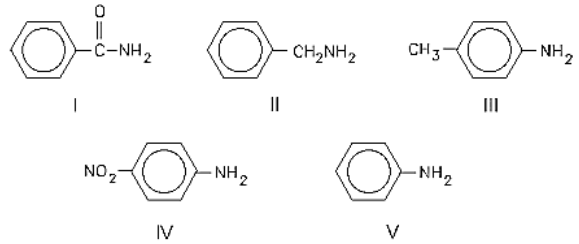
A) I
B) II
C) III
D) IV
E) V

27. What is the final product, C?



A) I
B) II
C) III
D) IV
E) V

28. Which of the following compounds would be the strongest base?



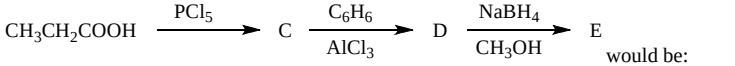
A) I
B) II
C) III
D) IV
E) V

29. Which would be the weakest base?
A) p-Methylaniline
B) p-Methoxyaniline
C) Hexylamine
D) p-Nitroaniline
E) Dipropylamine

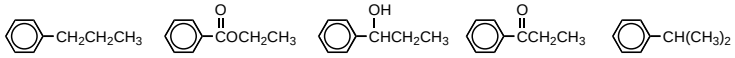
30. LSD is a common abbreviation for:
A) lead stroncium dichromate
B) least square differences method
C) lecithin sulfonium dichloride
D) lithium sulfodioxide
E) lysergic acid diethylamide

31. A correct name for is?
A) 3-Benzylpropanone
B) 3-Phenylpropanal
C) 3-Benzylpropanal
D) Nonanone
E) Nonanal

32. The product, E, of the following reaction sequence,

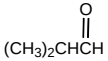


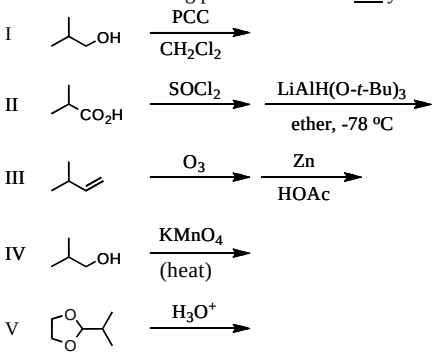
would be:



I II III IV V

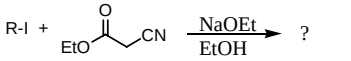
A) I
B) II
C) III
D) IV
E) V

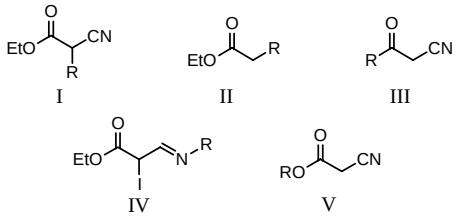
33. Which of the following procedures would **not** yield  as a product?



A) I
B) II
C) III
D) IV
E) V

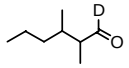
34. Which product can be obtained via the following generalized reaction?

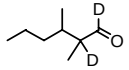


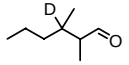


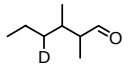
A) I
B) II
C) III
D) IV
E) V

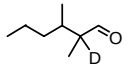
35. Which compound would be formed when 2,3-dimethylhexanal is treated with a solution of NaOD in D_2O?

A) 

B) 

C) 

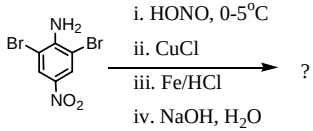
D) 

E) 

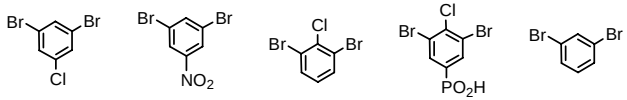
36. Which reagent could be used to separate a mixture of aniline ($PhNH_2$) and toluene ($PhCH_3$)?

A) $KMnO_4$ in H_2O
B) Dilute NaOH
C) Dilute $NaHCO_3$
D) $Ag(NH_3)_2OH$
E) Dilute HCl

37. What compound is likely to be obtained via the following reaction sequence?



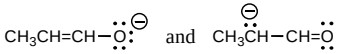
i. HONO, 0-5°C
ii. CuCl
iii. Fe/HCl → ?
iv. NaOH, H_2O
v. HONO, 0-5°C
vi. H_3PO_2

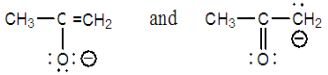


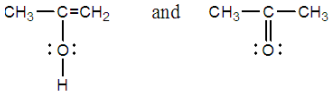
I II III IV V

A) I
B) II
C) III
D) IV
E) V

38. Which of the following pairs represent tautomers?

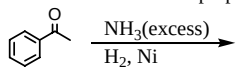
A) 

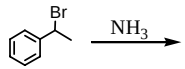
B) 

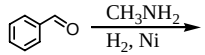
C) 

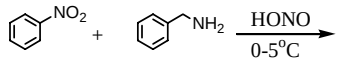
D) All of these
E) None of these

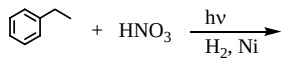
39. Which is the best method to prepare  ?

A) 

B) 

C) 

D) 

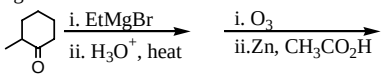
E) 

Name _____ Last four numbers of the ID _____

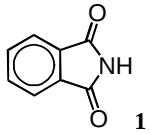
Part B

40. (**10 marks**) Prepare hexane-2,5-dione from acetone and acetoacetic ester ($CH_3C(O)CH_2CO_2CH_3$). Show a mechanism of <u>either</u> the first <u>or</u> the last step. (A tip: α-bromoacetone can be a possible intermediate).

41. (**10 marks**) Complete the following reaction sequence, giving structural details of all significant intermediates and the mechanism of the first step.



42. (**10 marks**) When phthalimide (**1**) is treated with a strong base and 3-bromopentane, two products (**2** and **3**) are formed. Compound **2** is a liquid with a molecular formula of C_5H_{10} that showed an infrared peak at 1620 cm^{-1}. Compound **3** has the molecular formula of $C_{13}H_{15}NO_2$. When **3** is heated with hydrazine, compound **4** is isolated ($C_5H_{13}N$) and its expected ^{1}H NMR spectrum (with integrated peak areas) is shown below.

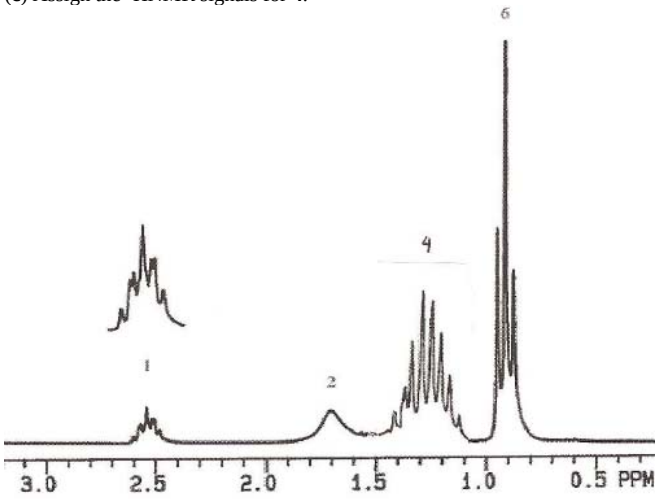


1

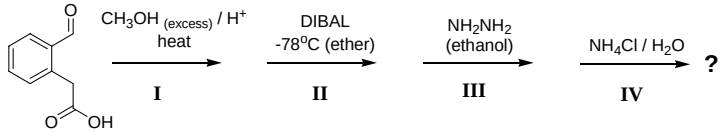
(**a**) Show structures for **2**, **3** and **4**.

(**b**) Give an arrow-pushing rationale for the formation of **2** ***and*** **3**.

(**c**) Assign the ^{1}HNMR signals for **4**.



43. (**10 marks**) Show the final product and all intermediates of the following reaction sequence (remember that DIBAL is AlH(*i*-Bu)$_2$ and NH_4Cl is weakly acidic). Show the arrow pushing mechanism of step (III). What intramolecular cyclization could happen in the last step (show the structure for **1** extra mark)?



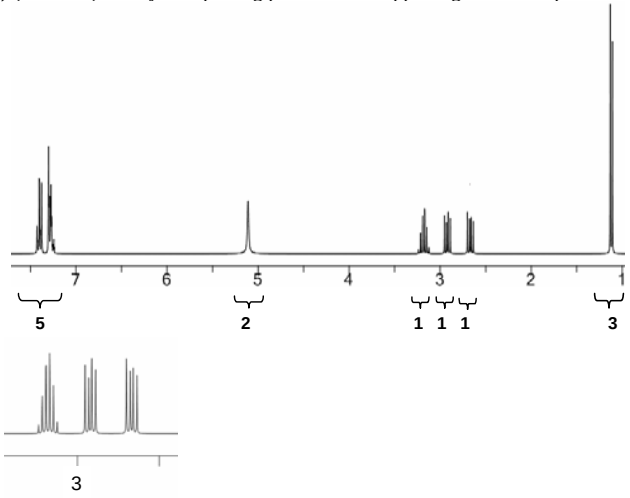
44. Benzaldehyde was treated with nitroethane and dilute base. When worked up, the product A ($C_9H_9NO_2$) showed 7 signals in the ^{13}C NMR spectrum.

Compound A was then subjected to hydrogenation over a platinum catalyst to give B that showed an exact mass measurement of the parent ion of 135.1049 and gave the ^{1}H NMR shown below.

C	12.0000
H	1.0078
N	14.0031
O	15.9949

a) (7 **marks**) Justify the formation of A with curved arrows and show structures for **A** and **B.**

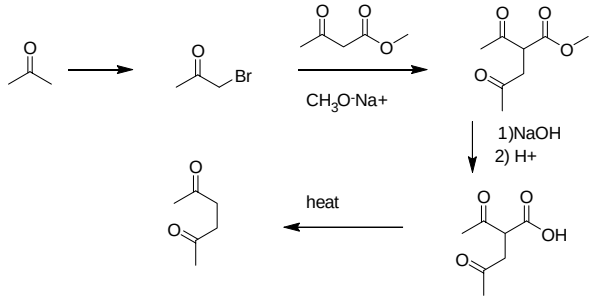
b) (**4 marks**) Justify the splitting pattern in the 3ppm region of the spectrum.



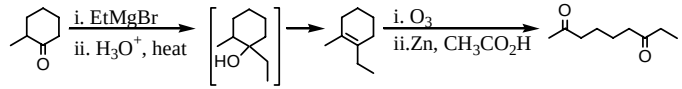
Answer Key

1. A
2. C
3. C
4. C
5. D
6. B
7. B
8. B
9. E
10. D
11. B
12. D
13. B
14. E
15. A
16. E
17. B
18. A
19. A
20. E
21. D
22. D
23. D
24. D
25. E
26. A
27. C
28. B
29. D
30. E
31. B
32. C
33. D
34. A
35. E
36. E
37. C
38. C
39. A

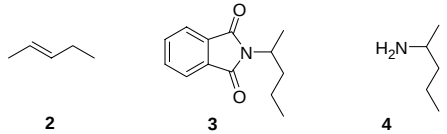
40.



41.

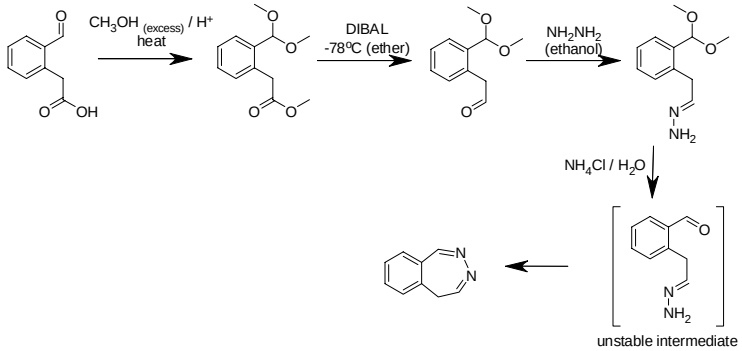


42.



2 **3** **4**

43.



44.

A B

The splitting is due to unequivalent protons in alpha position to Ph group (diastereotopic protons) which are next to the chiral centre (amino-substituted carbon)