AK

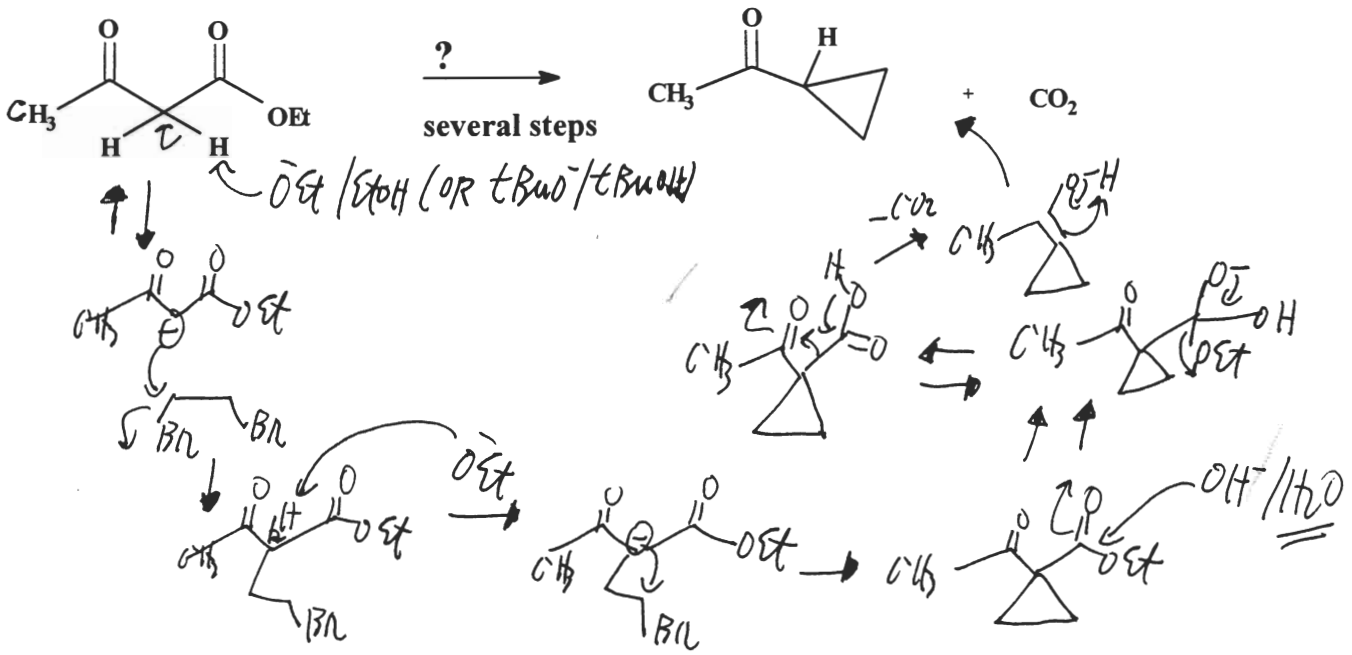
Columbia University **C99ORG23.DOC** **Chem S3444Q** **Summer 99**
Professor Irving J. Borowitz **Exam No. 3** ANSWER KEY **Aug 3, 1999**

Name: _____ ***Grade:*** _____

Please use a **non-red** pen. Answer questions in the provided space. If you write any answers on the back of the page, indicate this on the **front** of that page. Points appear in parentheses ( ). ***Good Luck!***

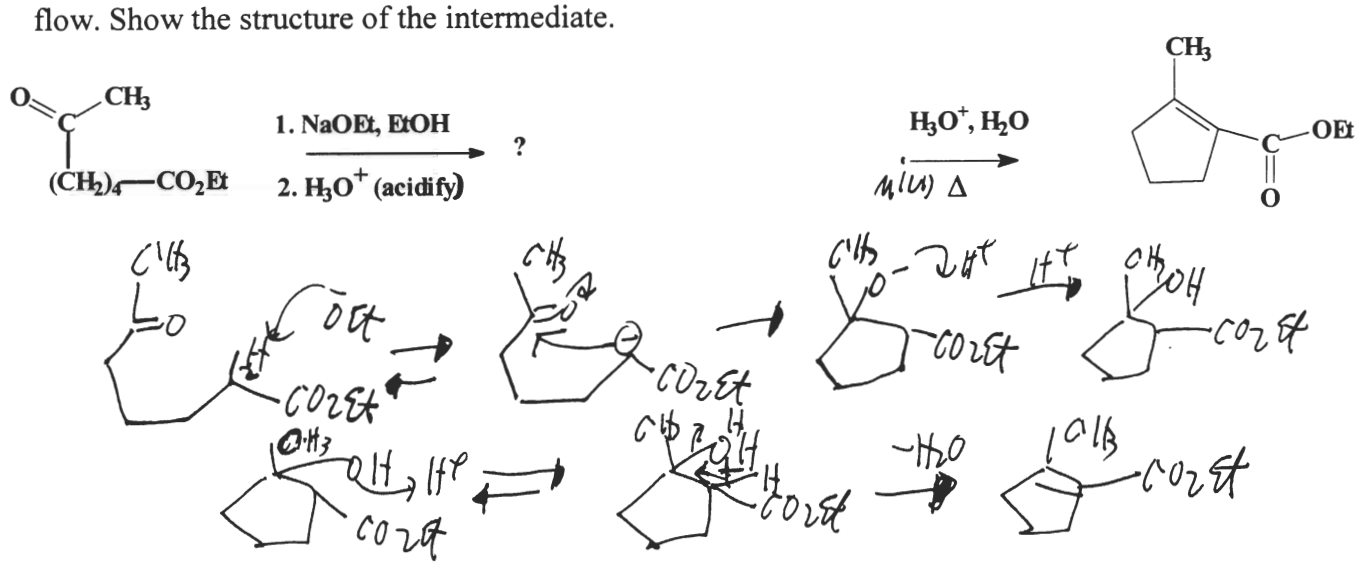
Question	Max. Pts.	Pts	Question	Max. Pts	Points
1. 6+6	= 12		4. 4+4+7+4	= 19	
2. 6+6+3+3+3+2	= 23		5. 3+(4+5)+4	= 16	
3. 4+4+4+4	= 16		6. 4+3+3+2+2	= 14	
				Total = 100	

1. (*12*) a. Write a detailed step-by-step mechanism and fill in the reagents and synthetic steps necessary to complete the following reaction. Use arrows to show electron flow.



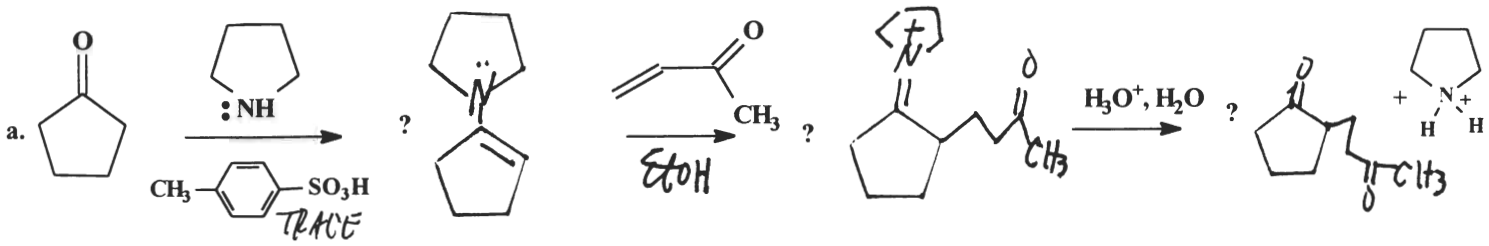
6

b. Write a detailed step-by-step mechanism for the following conversion. Use arrows to show electron flow. Show the structure of the intermediate.



6

2. **(23)** Fill in the missing reagents, intermediates, and/or products for the following reaction sequences:

a. 

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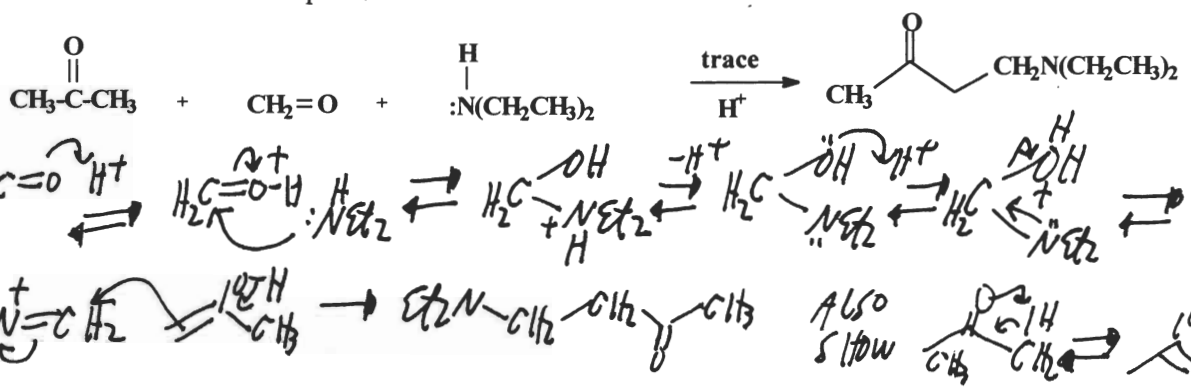
b. Fill in all mechanistic steps.



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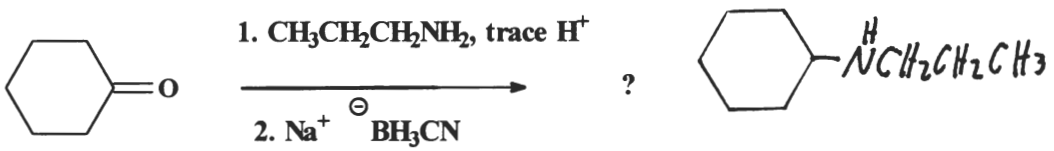
c. 

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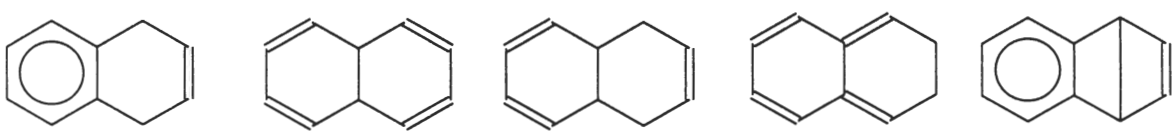
d. Circle the correct product if benzyne is generated in the presence of 1,3-butadiene:



(A) B C D E

3pt **Answer = A**

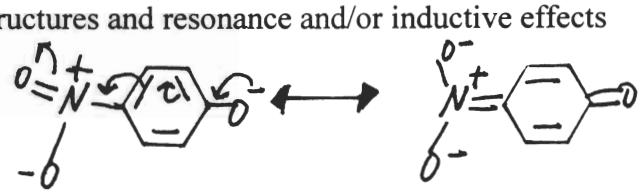
e. Which one of the following compounds would you expect to be the strongest acid?

1. CH_3OH
2. $C_6H_5CH_2OH$
3. para-CH_3-C_6H_4-OH
4. C_6H_5OH
5. Para-NO_2-C_6H_4-OH **(strongest)**

3

f. Explain your answer, using structures and resonance and/or inductive effects

The negative charge is dispersed onto nitro group's oxygen



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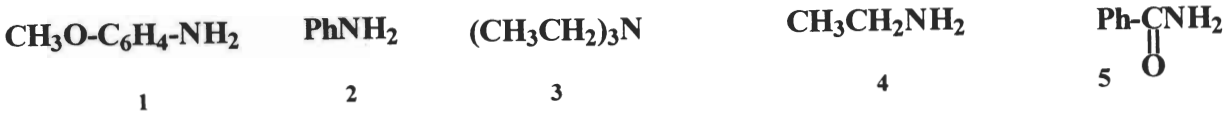
3 (16) a. Rank the following compounds in order of decreasing basicity (most basic compound first) *in the gas phase.*



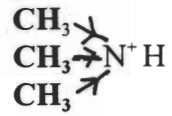
4

Rank: 3 > 4 > 1 > 2 > 5

b. Explain your answer for the **strongest base** and for **the weakest base** using structures involving resonance and/or inductive effects.

Strongest Base Rationale:

Tertiary amine strongest **Inductive effects of 3 alkyl groups stabilize protonated form**

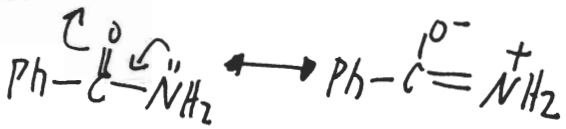


andmake pair of e⁻ on N more AVAILABLE

2

Weakest Base Rationale:

No. 5 amide is the weakest: nitrogen's non-bonding electron pair is dispersed onto more electro-negative oxygen



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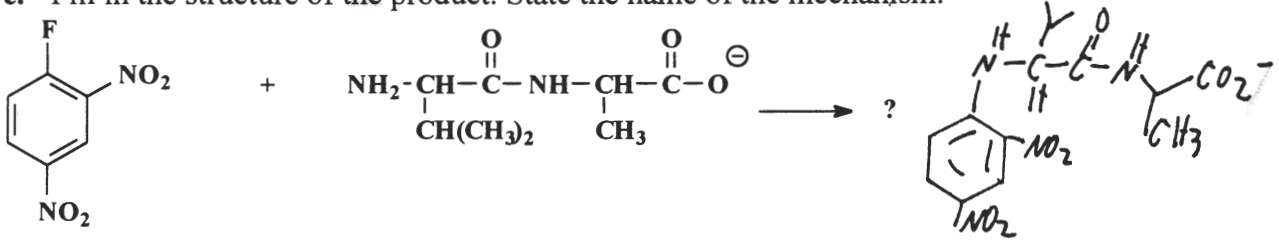
c. Fill in the structure of the product. State the name of the mechanism.



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Mechanism Name: **aromatic nucleophilic substitution**.

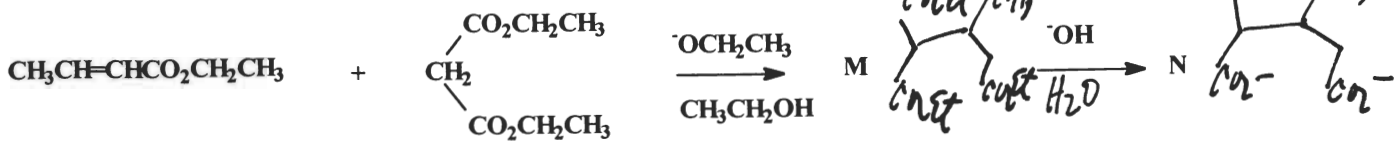
1

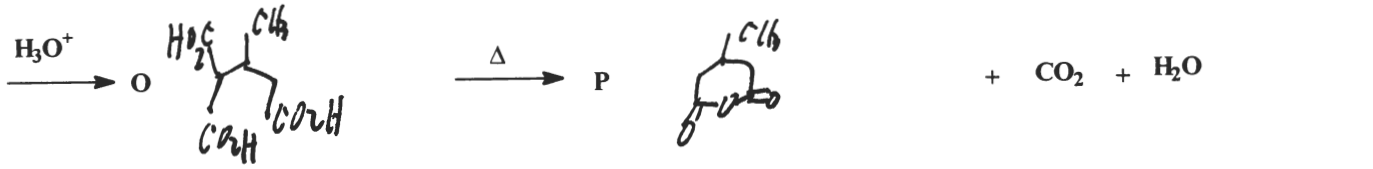
d. Why is CH_3ONa **not used** in the Claisen condensation of ethyl acetate with itself?

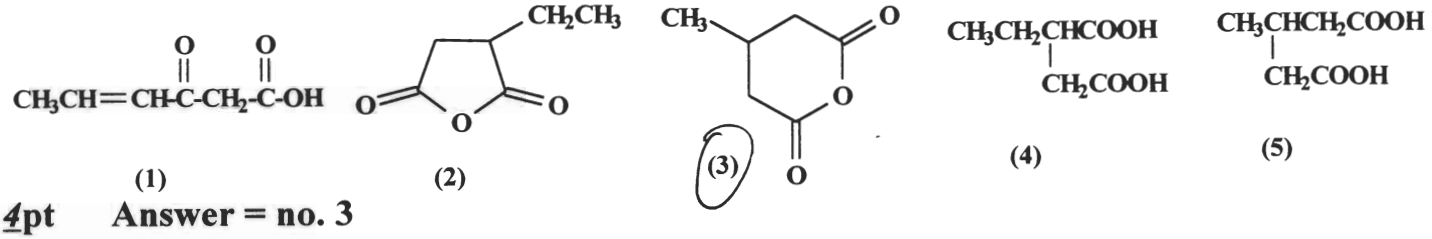
1. CH_3ONa is a weaker base than the CH_3CH_2ONa (EtONa) that is used
2. CH_3ONa is more difficult to prepare than is EtONa.
3. CH_3O^- would abstract a proton from the ethyl group of the ester
4. Use of CH_3ONa would result in transesterification in the product

4 **correct answer = 4**

5 4. **(19)** a. Predict the product, **P**, of the following reaction sequence.



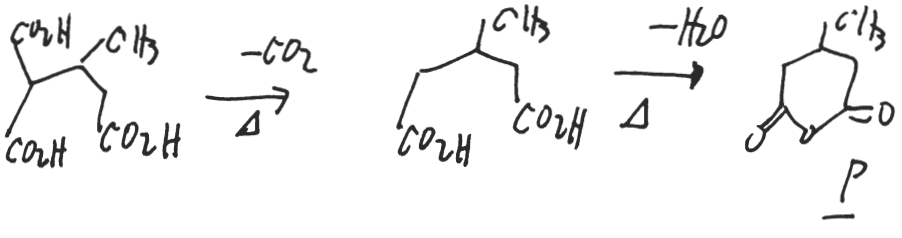




(1) (2) (3) (4) (5)

4pt Answer = no. 3

b. Show the structure of **O** and the mechanism of the conversion of **O** to **P**. Note that more than 1 step may be required.



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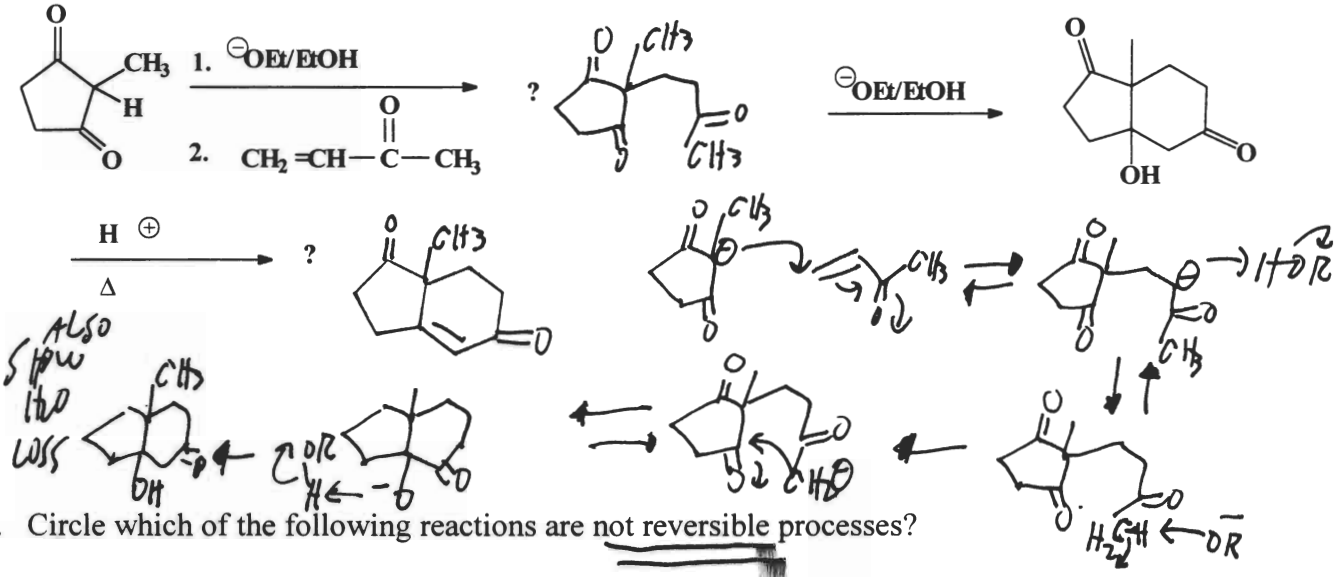
c. Fill in the missing intermediates and product. Indicate the mechanism by arrows showing the direction of electron flow.



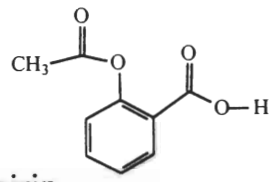
7

d. Circle which of the following reactions are not reversible processes?

1. Claisen condensation
2. Aldol condensation
3. Conversion of chlorobenzene to phenol with (a) NaOH, H_2O at 350°C, (b) acidification **
4. Acetal formation
5. Base catalyzed ester hydrolysis **

4 **Answers= No. 3, 5**

5. (16) a. Choose the best method to synthesize aspirin:



aspirin

(1) CH_3COOPh, CO_2, Δ ; then H^+

(2) Ph-COOH, CH_3COOH, $AlCl_3$, Δ ; then H_2O

(3) PhOH, ^-OH, CO_2, Δ , pressure; then H_3O^+; then $(CH_3C)_2O$ (O)

(4) Ph-OH, CO_2, H_3O^+; separate isomers; then CH_3COOH, $AlCl_3$

(5) CH_3COOPh, HCOOEt, EtO^-; then H_3O^+; then ^-OH

3pt **Answer = no. 3**

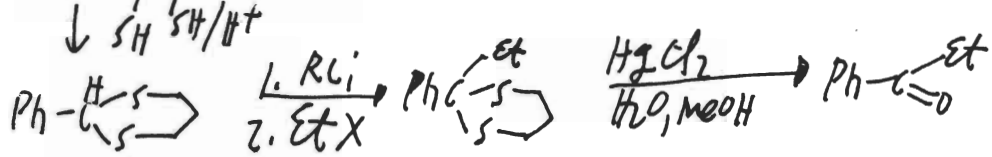
b. Using any necessary reagents, do the following conversions: Show all intermediate, reagents.

(1) 1-butanol ⟶ pentylamine

$$C_4H_9\text{-}OH \xrightarrow{HBr \text{ or } PBr_3} C_4H_9\text{-}Br \xrightarrow{NaCN} C_4H_9CN \xrightarrow{H_2 / Pt} C_4H_9CH_2NH_2$$

4

(2) $PhCH{=}O \longrightarrow PhC(=O)C_2H_5$

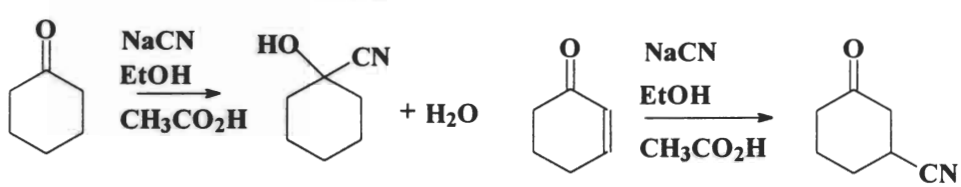


ACCEPT ALSO: $PhCH{=}O \xrightarrow{oxid.} Ph\text{-}CO_2H \xrightarrow{SOCl_2} PhCOCl \xrightarrow[OR]{Et_2CuLi} PhCOEt$

Et_2Cd NOT $EtMgBr$, not $EtLi$

5

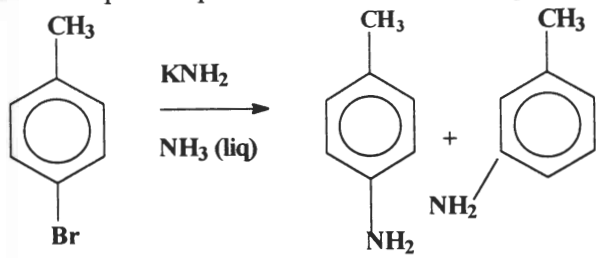
c. Why does cyclohexanone give 1,2 addition with cyanide while cyclohexenone gives 1,4 addition ? Explain with words and the mechanisms involved.



1,4-Addition of CN^- is a reversible Michael addition, thermodynamically controlled. It proceeds through a resonance-stabilized enolate intermediate. The 1,2-addition of CN^- to C=O, also reversible, is less favorable since it removes the resonance-stabilized carbonyl group.

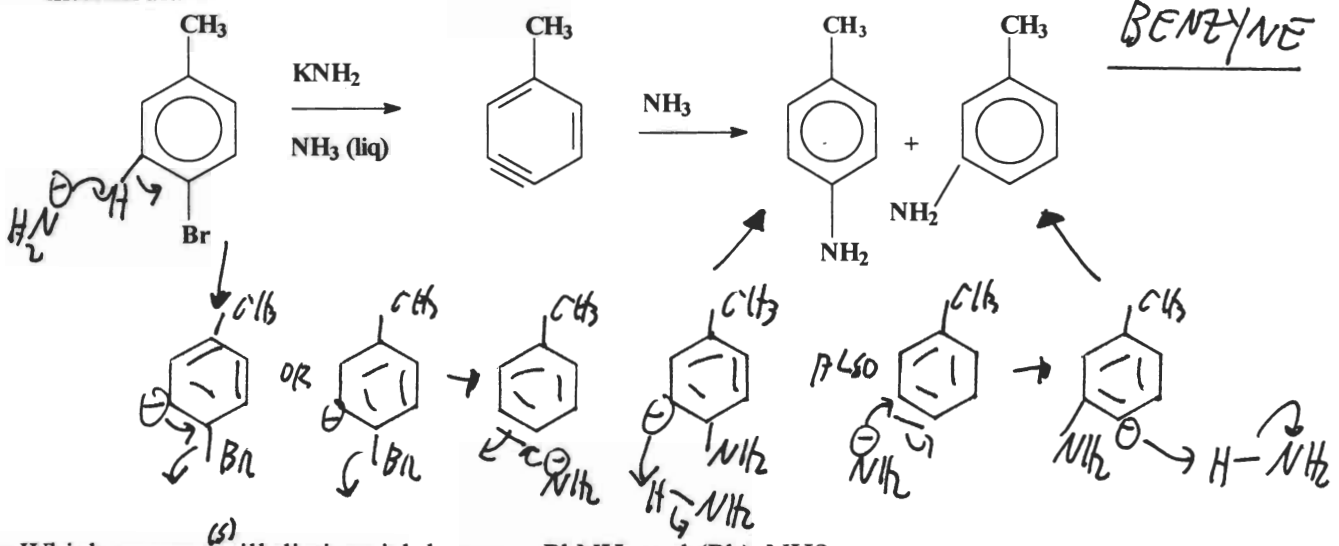
4

6.**(14) a.** Write the expected products in the following reaction:



4pt

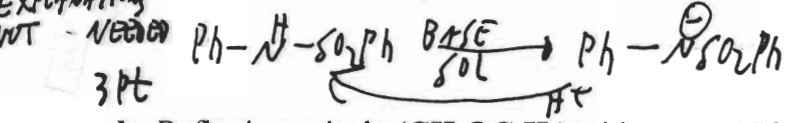
b. Explain your answer in **6a** by writing the mechanism of the reaction involved and any important intermediate:



3

c. Which reagent will distinguish between $PhNH_2$ and $(Ph)_2NH$?

1. conc. HNO_3
2. aqueous
3. **$PhSO_2Cl$/ OH^-, then H_3O^+ (Hinsberg test:** 1° amine gives a sulfonamide which is base soluble, acid insoluble; 2° amine gives sulfonamide insol in OH^- and in acid)
4. $KMnO_4$
5. Br_2 / CCl_4



d. Refluxing anisole **($CH_3OC_6H_5$)** with **excess HCl** will yield which one of the following product mixtures (underline correct answer).

1. $C_6H_5Cl + CH_3OH$
2. $C_6H_5OH + CH_3OH$
3. $C_6H_5Cl + CH_3Cl$
4. $C_6H_5OH + CH_3Cl$
5. **No reaction** (HCl is not strong enough an acid. HBr, HI work).

2

e. Circle the one or more compounds below that readily lose **CO_2** at 25°C or upon some warming:

1. **$CH_3CH_2OCH_2CO_2H$**
2. **$(CH_3)_2NCO_2H$**
3. **$C_6H_5CH_2CO_2H$**
4. **$CH_2{=}CHCO_2H$**
5. **$CH_3C(=O)CH_2CO_2H$**

2 pt. ***Answer=*** **no. 5, 2 (no. 5 forms an enol, no. 2 has an electronegative nitrogen).**