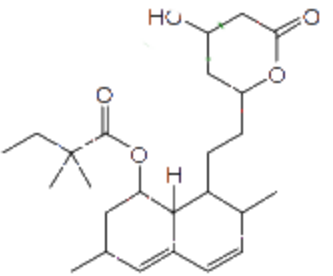
Please ensure that you have entered **code 111** *on your answer sheet.*

Questions 1 and 2 refer to the compound on the right, *simvastatin*, a drug used for the treatment of high cholesterol.



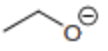
1. What is NOT correct about *simvastatin*?

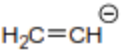
   A It contains a conjugated diene
   B It contains a primary alcohol
   C It contains an ester and a lactone
   D It contains a secondary alcohol
   E It contains a quaternary carbon atom

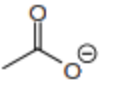
2. *Simvastatin* contains how many non-bonding electron pairs, and how many sp^2-hybridized carbon atoms?

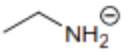
	Non-bonding pairs	sp^2 carbon atoms
A)	10	6
B)	10	4
C)	6	6
D)	6	2
E)	8	4

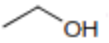
3. Which one of the following is the *most* stable?

A) 

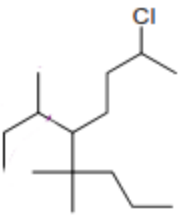
B) 

C) 

D) 

E) 

4. What is a proper IUPAC name for the following compound?



A 4,4-dimethyl-5-*tert*-butyl-8-chlorononane

B 5-*tert*-butyl-2-chloro-6,6-dimethylnonane

C 5-*sec*-butyl-8-chloro-4,4-dimethylnonane

D 8-chloro-5-isopropyl-4,4-dimethylnonane

E 5-*sec*-butyl-2-chloro-6,6-dimethylnonane

5. How many constitutional isomers exist for C_4H_9Br?

A 3

B 4

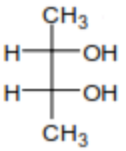
C 5

D 2

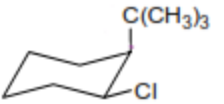
E 6

6. Which one of the following is shown in its most stable conformation?

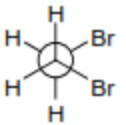
A)



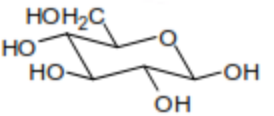
B)



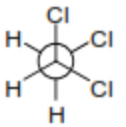
C)



D)



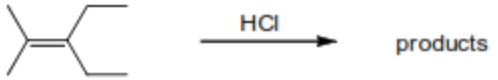
E)



7. Which one of the following has the greatest number of *cis/trans* isomers?

A 1,2-dimethylcyclohexane
B 3,4-dichlorocyclopentene
C 2,4-heptadiene
D 3-methylcyclopentane
E 1,3-butadiene

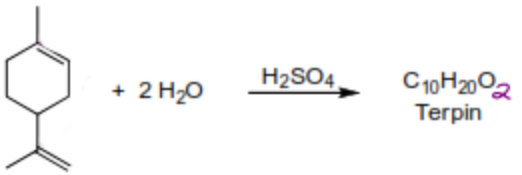
8. The two products formed in the reaction below can be correctly described as?

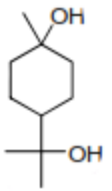


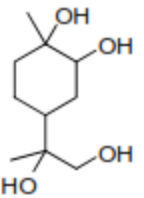
1. Constitutional isomers
2. Regioisomers
3. Stereoisomers

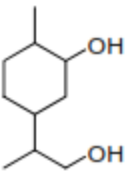
A All of 1, 2, and 3
B 1 only
C 2 and 3 only
D 2 only
E 1 and 2 only

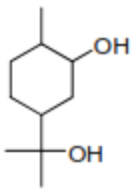
9. *Terpin* is prepared commercially by the acid-catalyzed hydration of limonene. What is the structural formula of *terpin*?

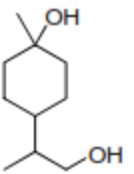


A)


B)


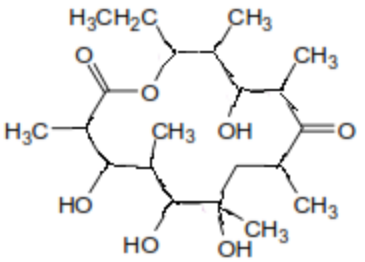
C)


D)


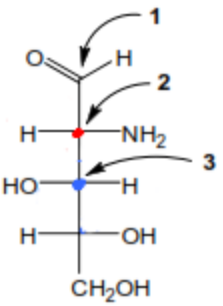
E)


10. How many stereocentres are present in the antibiotic *erythronolide B*?

A 7
B 10
C 11
D 12
E 8



11. If the indicated carbon atoms in the molecule shown below are stereocentres, assign *R/S* configurations to them.



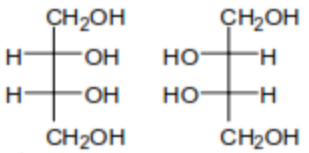
	1	2	3
A)	*not a stereocentre*	*R*	*R*
B)	*not a stereocentre*	*R*	*S*
C)	*not a stereocentre*	*S*	*R*
D)	*S*	*S*	*R*
E)	*not a stereocentre*	*S*	*S*

12. How many stereoisomers exist for 1,3,5-trichlorocyclopentane?

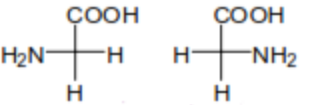
A 6
B 2
C 5
D 4
E 8

13. Which two compounds rotate plane-polarized light to exactly the same magnitude, but in opposite directions?

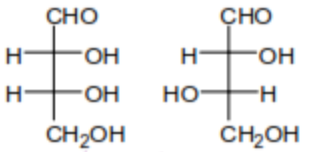
A



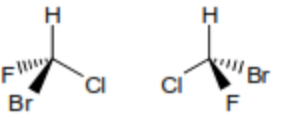
B



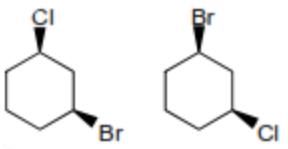
C



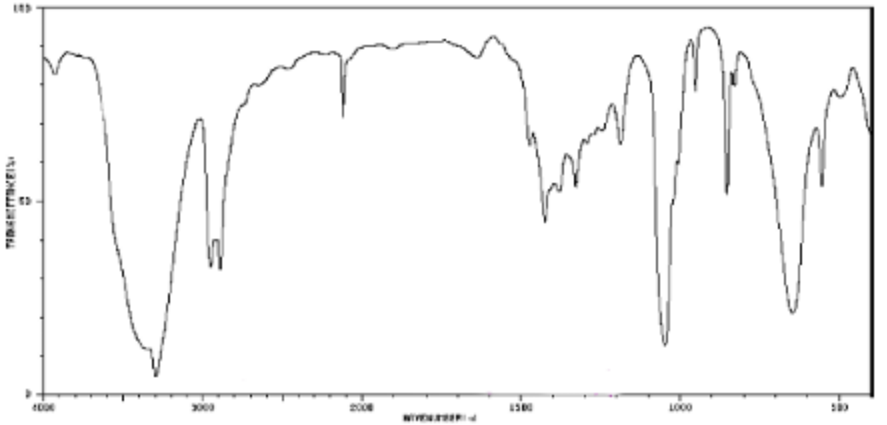
D

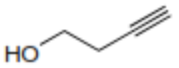


E

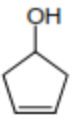


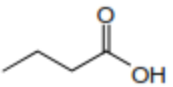
14. The IR spectrum shown below corresponds to which compound?

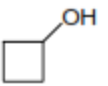


A) 

B) 

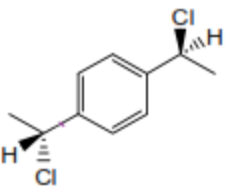
C) 

D) 

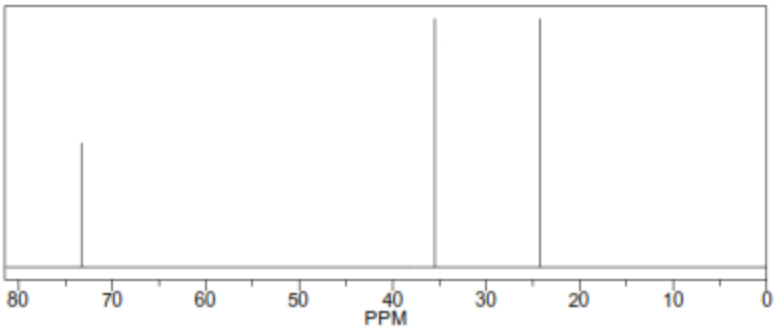
E) 

15. How many signals are in the ^{13}C-NMR spectrum of the compound below?

A 8
B 4
C 3
D 6
E 10



16. A compound with the formula C_5H_6 reacts with water in the presence of an acid catalyst to produce a compound with the ^{13}C-NMR spectrum shown below. What is a possible structure of the C_5H_6 compound?



A) 

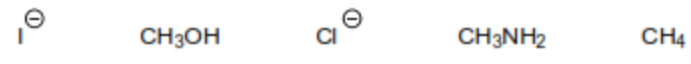
B) 

C) 

D) 

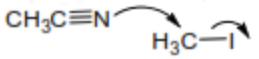
E) 

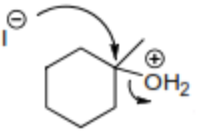
17. Rank the following from the best to the worst nucleophile.

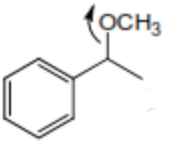


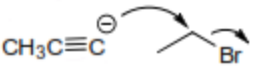
	Best		⟶		Worst
A)	1	3	5	4	2
B)	1	3	4	2	5
C)	5	4	2	3	1
D)	3	1	4	2	5
E)	4	2	5	3	1

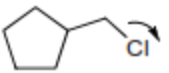
18. Which one of the following processes occurs fastest at room temperature?

A) 

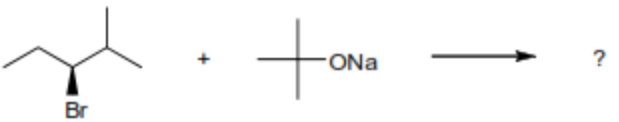
B) 

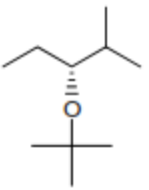
C) 

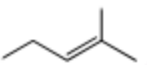
D) 

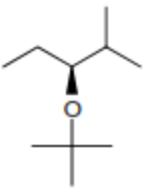
E) 

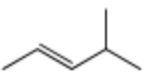
19. What is the major product of the following reaction?



A) 

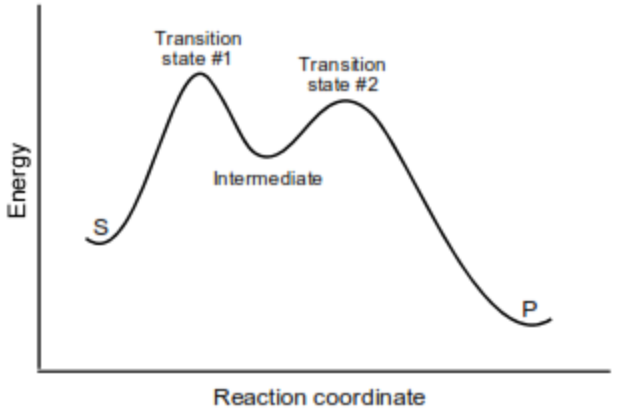
B) 

C) 

D) 

E) 

20. Consider the reaction coordinate diagram below for the conversion of starting materials (S) to products (P).

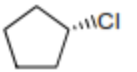


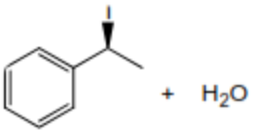
Which of the following modifications would increase the overall rate of the reaction?

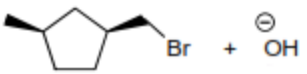
1. Decreasing only the energy of transition state #1
2. Decreasing only the energy of the products (P)
3. Increasing only the energy of the intermediate

A 3 only
B None of them
C 1 and 2 only
D 2 only
E 1 only

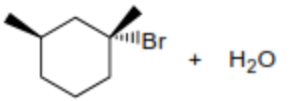
21. Which pair of reagents will react to give a racemic mixture of products?

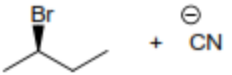




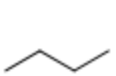


D)

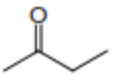




22. Rank the following from the lowest to the highest boiling point.



1

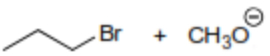


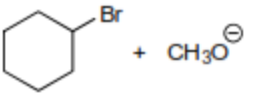
2

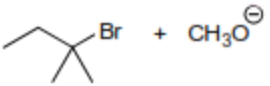
3

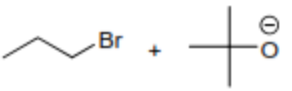
	Lowest	⟶	Highest
A)	3	2	1
B)	2	1	3
C)	2	3	1
D)	1	2	3
E)	1	3	2

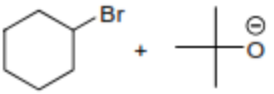
23. Which one of the following reactions gives the lowest yield of alkene products?



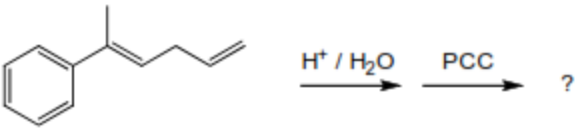




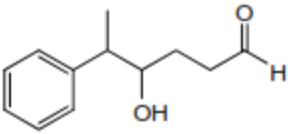




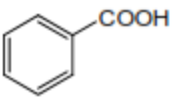
24. What is the major product of the following reaction sequence?



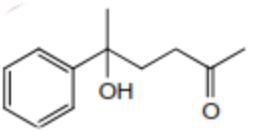
A)



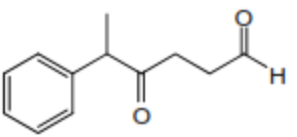
B)



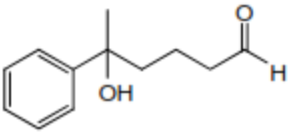
C)



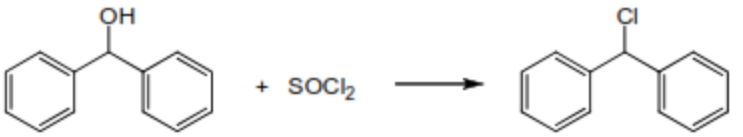
D)

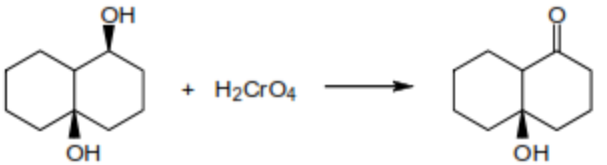


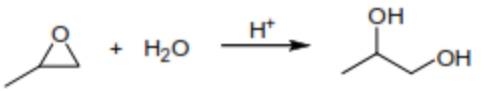
E)

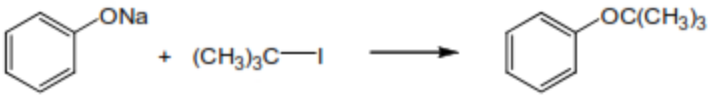


25. Which one of the following does NOT give a good yield of the product shown?

A) 

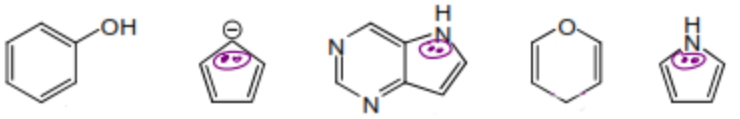
B) 

C) 

D) 

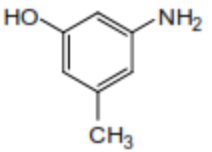
E) $CH_3CH_2OH + HCl \longrightarrow CH_3CH_2Cl$

26. How many of the following are aromatic?



A 4
B 3
C 5
D 2
E 1

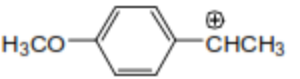
27. Which of the following are NOT correct IUPAC names for the compound below?

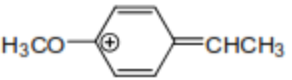


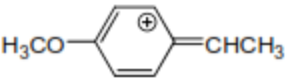
1. 1-amino-3-hydroxy-5-methylbenzene
2. 2-amino-4-hydroxytoluene
3. 3-hydroxy-5-methylpyridine
4. 2-amino-4-methylphenol

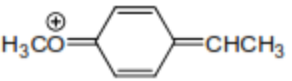
A) 4 only
B) 2, 3, and 4 only
C) All of 1, 2, 3, and 4
D) 1 only
E) 1 and 3 only

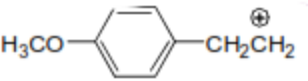
28. Which one of the following is NOT a stabilizing resonance structure of the cation on the right?

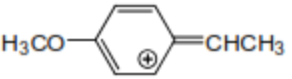


A) 

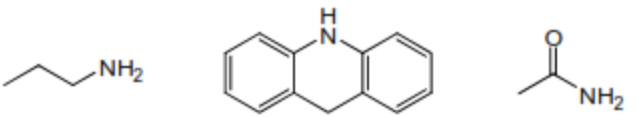
B) 

C) 

D) 

E) 

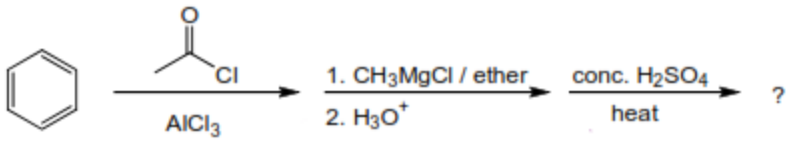
29. Rank the following from the weakest to the strongest base.

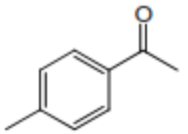


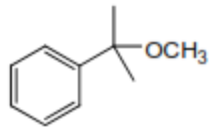
1 **2** **3**

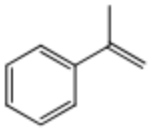
	Weakest	⟶	Strongest
A)	**1**	**2**	**3**
B)	**3**	**2**	**1**
C)	**2**	**3**	**1**
D)	**3**	**1**	**2**
E)	**1**	**3**	**2**

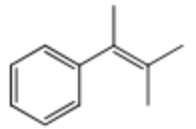
30. What is the product of the following reaction sequence?

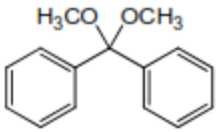


A)


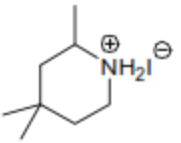
B)


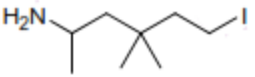
C)


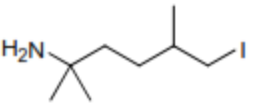
D)


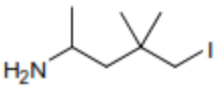
E)


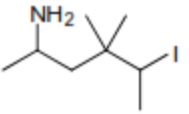
31. Which acyclic amine, when heated, forms the product below?

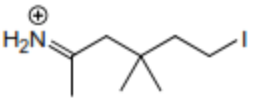


A) 

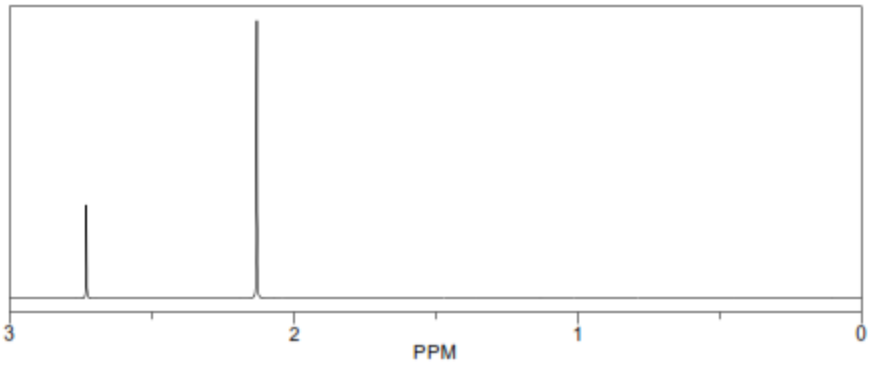
B) 

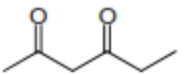
C) 

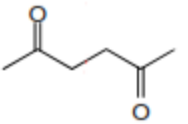
D) 

E) 

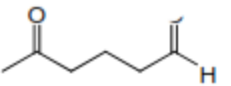
32. Which compound has the ^{1}H-NMR spectrum shown?

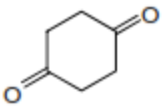


A) 

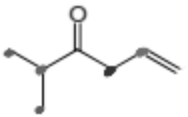
B) 

C) 

D) 

E) 

33. What signals are present in the complete ^{1}H-NMR spectrum of the compound below?



A) d, 6H
m, 1H
d, 2H
m, 1H
d, 1H
d, 1H

B) d, 3H
d, 3H
m, 1H
d, 2H
m, 1H
d, 1H
d, 1H

C) d, 3H
d, 3H
m, 1H
d, 2H
m, 1H
d, 2H

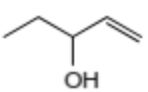
D) d, 6H
q, 1H
d, 2H
m, 1H
d, 1H
d, 1H

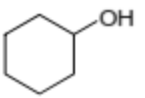
E) d, 6H
q, 1H
d, 2H
m, 1H
d, 2H

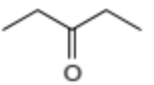
34. An unknown compound:

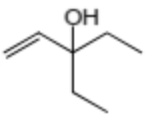
- Has the formula $C_nH_{2n}O$
- Does not react with Tollens' Reagent, $NaBH_4$, or $SOCl_2$
- Has no signals in the 160-200 ppm region of its ^{13}C-NMR spectrum
- Reacts with H_2/Pt to give a product that has three ^{1}H-NMR signals, a singlet, a doublet, and a quartet.

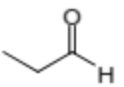
What could the unknown be?

A) 

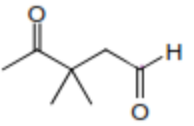
B) 

C) 

D) 

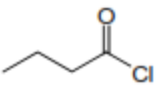
E) 

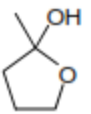
35. What is a correct IUPAC name for the compound below?

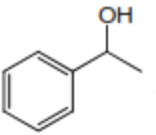


A 3,3-dimethyl-4-oxopentanal
B 2,5-dioxo-3,3-dimethylpentane
C 3,3-dimethyl-2,5-pentandione
D 3,3-dimethyl-1,4-pentanedione
E 2-oxo-3,3-dimethyl-5-pentanal

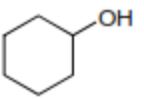
36. Which one of the following CANNOT be prepared from an aldehyde or a ketone using a nucleophilic addition reaction?

A) 

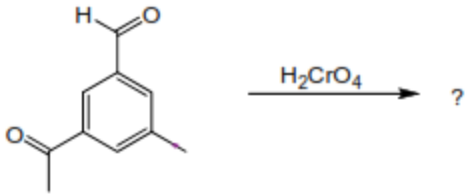
B) 

C) 

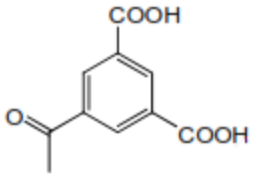
D) 

E) 

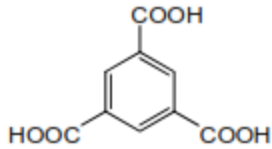
37. What is the product of the following reaction?



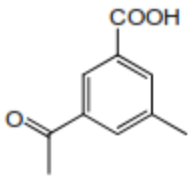
A)



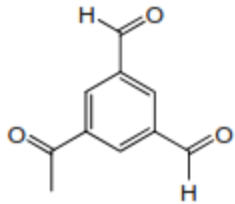
B)



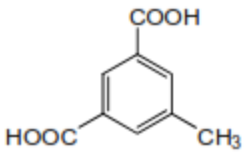
C)



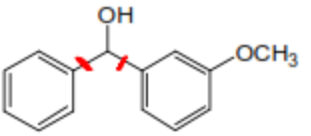
D)

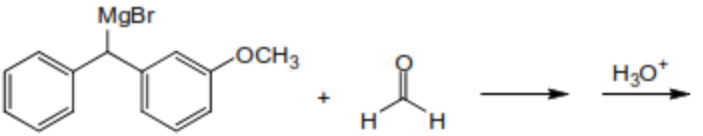


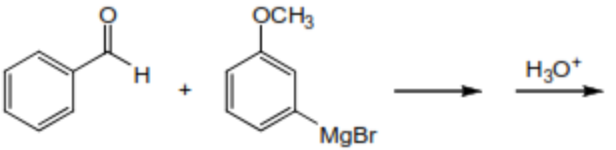
E)

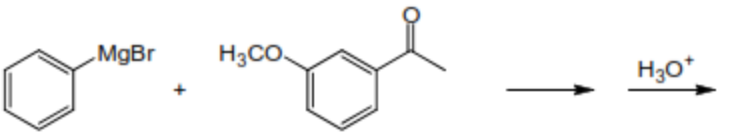


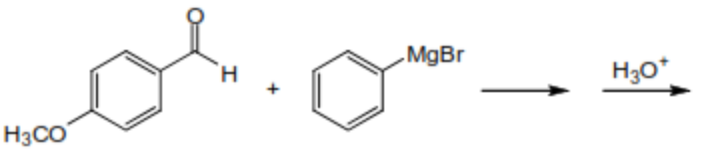
38. Which Grignard reaction gives the best yield of the compound shown on the right?

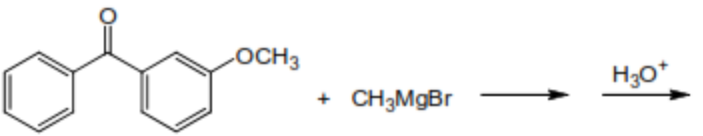




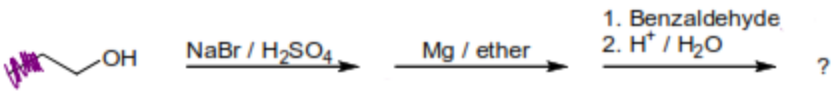


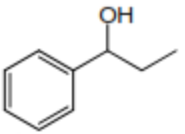




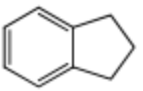


39. What is the product of the following reaction sequence?

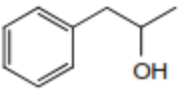




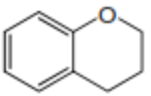
B)



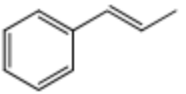
C)



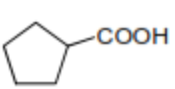
D)



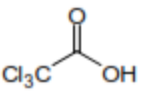
E)



40. Aqueous 0.1 M solutions of the four compounds below were prepared. Rank the solutions from the lowest to the highest pH.

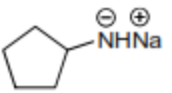


1



2

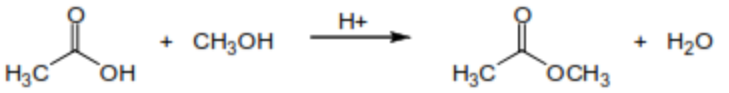
3

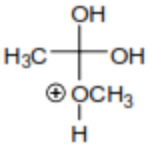


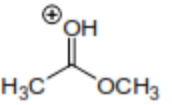
4

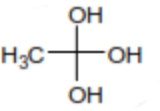
	Lowest	⟶		Highest
A)	2	1	3	4
B)	2	1	4	3
C)	3	4	2	1
D)	4	3	2	1
E)	3	4	1	2

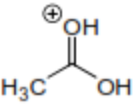
41. Which one of A – E is NOT involved in the following reaction?

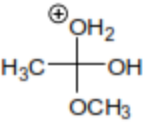


A)


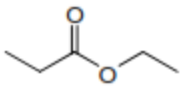
B)


C)


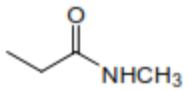
D)


E)


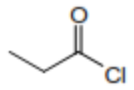
42. Rank the following compounds, from the most reactive to the least reactive, towards nucleophilic acyl substitution.



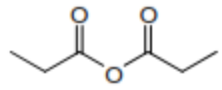
1



2



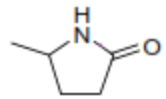
3



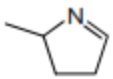
4

	Most reactive	⟶		Least reactive
A)	3	1	4	2
B)	4	1	3	2
C)	2	4	3	1
D)	1	3	2	4
E)	3	4	1	2

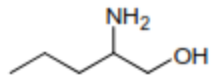
43. What is the product formed when the compound on the right is hydrolyzed and then reduced with $LiAlH_4$?



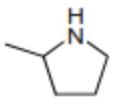
A)



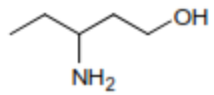
B)



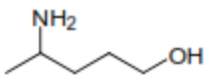
C)



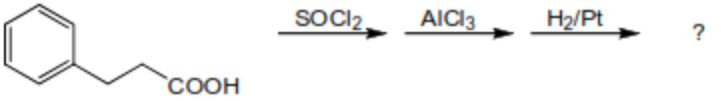
D)

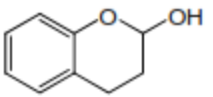


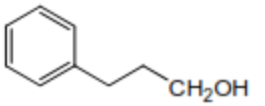
E)

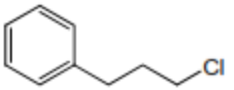


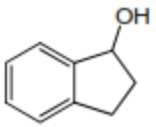
44. What is the product of the following reaction sequence?

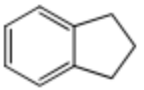


A)


B)


C)


D)


E)


45. A positive $KMnO_4$ test for alkenes is indicated by the precipitation of…

A Mn^{2+}
B KOH
C MnO_2
D Mn_2O_7
E $KMnO_6$

46. What is the primary purpose of the piece of glassware shown below?

A) It is where the chemical reactions take place while the mixture is hot
B) It slows the cooling of hot vapours
C) It separates the organic product from the water during a distillation
D It collects the distillate of a small-scale distillation
E) It is used for salting out an organic compound in an aqueous mixture

47. An aqueous solution contains 48% HBr by weight. Therefore,

A 100 g of the solution contains 48 mL of HBr
B 100 mL of the solution weighs 48 g
C 100 mL of the solution contains 48 g of HBr
D 48 mL of the solution weighs 100 g
E 100 g of the solution contains 48 g of HBr

48. Which one of the following reacts most rapidly with $AgNO_3$ in ethanol?

None of the compounds will react

chlorobenzene

2-chlorobutane

2-chloro-2-methylpropane

1-chlorobutane

49. When a methyl ketone is treated with iodine and NaOH in the iodoform test, what is the yellow solid that precipitates?

A CHI_3

B CH_3I

C NaI

D CH_2I_2

E CI_4

50. How many of the compounds below give a positive ferric chloride test?

A 5

B 4

C 2

D 3

E 1