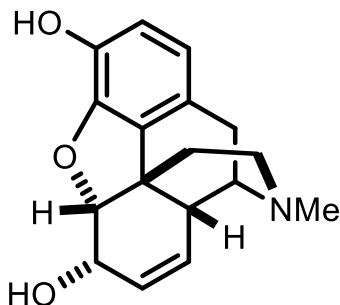


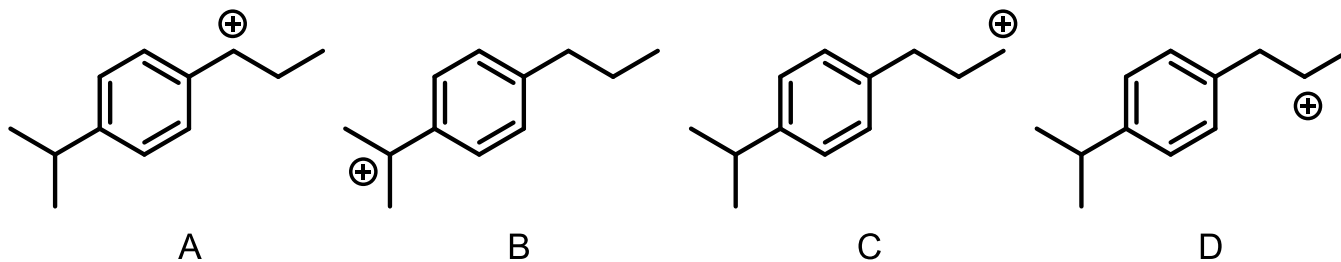
Problem Set #4, January 2020

Questions 61-64 refer to the structure of morphine, shown below:



61. How many degrees of unsaturation are in the molecule?
- 6
 - 7
 - 8
 - 9
 - 10
62. How many sp^2 -hybridized carbon atoms are in the molecule?
- 2
 - 4
 - 6
 - 8
 - 10
63. Which of the following functional groups are NOT in the molecule?
- ether
 - alcohol
 - phenol
 - lactam
 - amine
64. How many chiral centres (stereocentres) are in the compound?
- 3
 - 4
 - 5
 - 6
 - 7

65. Rank the following carbocations in order of decreasing stability (most stable to least stable).

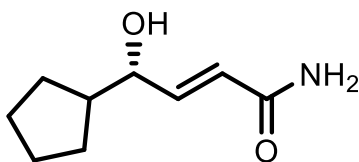


- A > B > D > C
- C > D > A > B
- B > A > C > D
- A > D > B > C
- B > A > D > C

66. In an infrared, a strong and sharp band around 1700 cm^{-1} suggests the presence of which functional group?

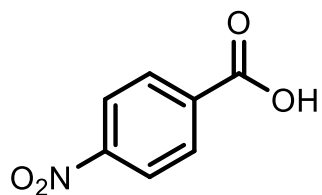
- alcohol
- alkyne
- carbonyl
- aromatic ring
- alkene

67. Which of the following names represents the following molecule?

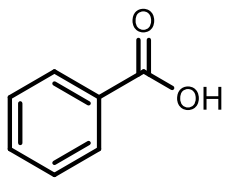


- (S,E)-4-cyclopentyl-4-hydroxybut-2-enamide
- (R,E)-4-cyclopentyl-4-hydroxybut-2-enamide
- (S,Z)-4-cyclopentyl-4-hydroxybut-2-enamide
- (S,E)-1-cyclopentyl-1-hydroxybut-2-enamide
- (R,E)-1-cyclopentyl-1-hydroxybut-4-enamide

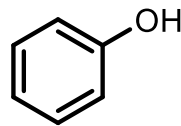
68. Rank the following compounds in order of decreasing acidity (most acidic to least acidic).



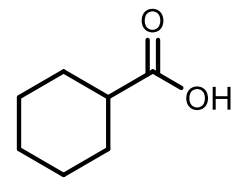
A



B



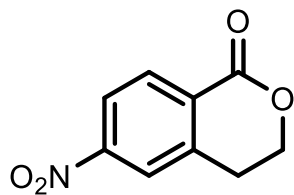
C



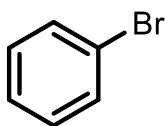
D

- A > B > D > C
- C > D > A > B
- C > D > B > A
- D > C > B > A
- A > B > C > D

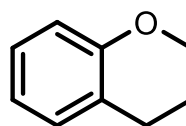
69. Rank the following compounds in order of decreasing rate of electrophilic aromatic substitution (fastest to slowest).



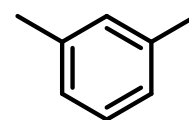
A



B



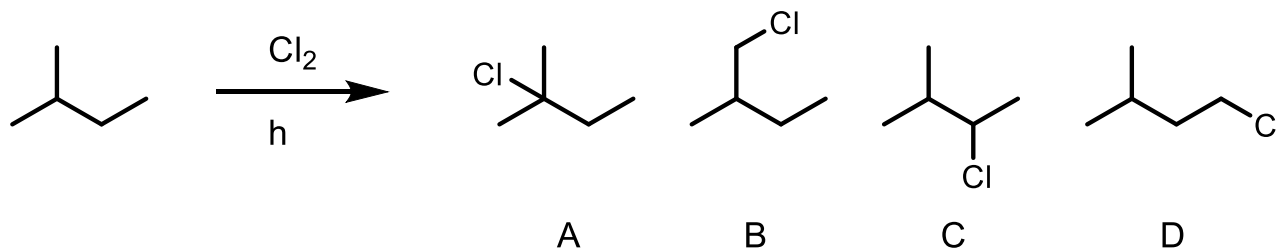
C



D

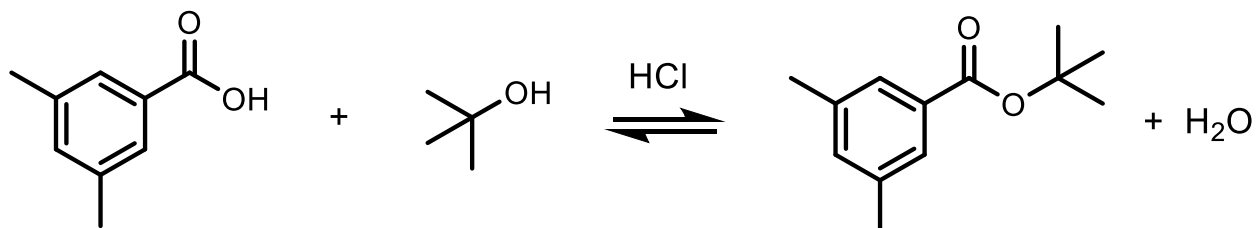
- A > B > D > C
- C > D > A > B
- C > D > B > A
- D > C > B > A
- A > B > C > D

70. Which is the most abundant monochlorination product formed when 2-methylbutane is reacted with Cl_2 gas in the presence of light? *Hint:* Consider the relative stability of the radical intermediate.



- A
- B
- C
- D
- Equal amounts of B and D

71. The reaction of a carboxylic acid with an alcohol in the presence of an acid catalyst is termed a Fischer esterification. An example is shown below:



3,5-dimethylbenzoic acid

tert-butyl 3,5-dimethylbenzoate

The purpose of the acid catalyst (HCl) is to:

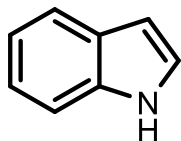
- Enhance the nucleophilicity of the water molecule
 - Enhance the electrophilicity of the carboxylic acid carbonyl carbon
 - Enhance the electrophilicity of the *tert*-butanol molecule
 - Shift the equilibrium of the reaction
 - Enhance the nucleophilicity of the *tert*-butanol molecule
72. How many singlet signals would you expect in the ^1H NMR spectrum for *tert*-butyl 3,5-dimethylbenzoate (product in Q71)?

- 4
- 5
- 6
- 7
- 8

73. Which of the following compounds are aromatic?



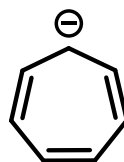
(i)



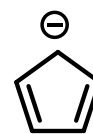
(ii)



(iii)



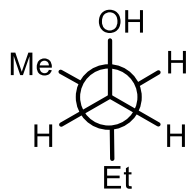
(iv)



(v)

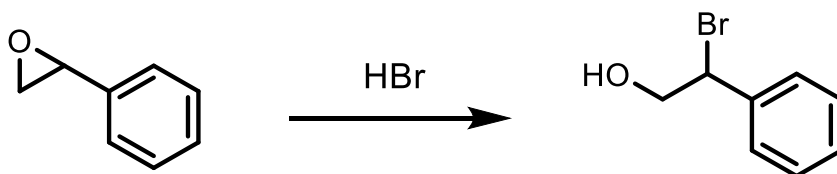
- i, iv, v
- ii, iv, v
- i, ii, iii
- ii, iii, iv
- ii, iii, v

74. The following structure represents which of the following?



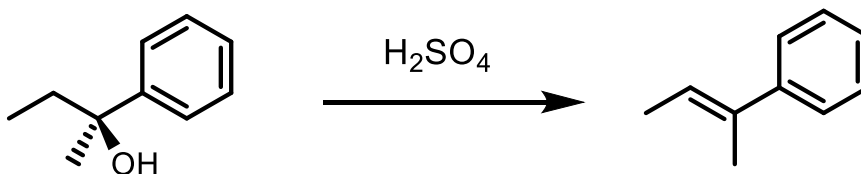
- a. An achiral molecule
- b. A single enantiomer
- c. A single diastereomer
- d. A racemic mixture
- e. A meso compound

75. The mechanism of the following reaction is best described as...



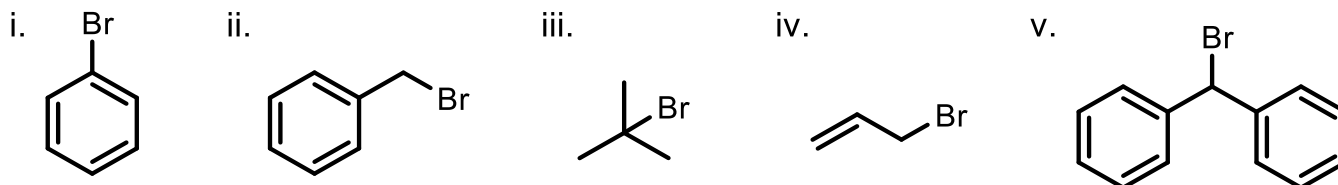
- a. S_N1
- b. S_N2
- c. E1
- d. E2
- e. radical

76. The mechanism of the following reaction is best described as...



- a. S_N1
- b. S_N2
- c. E1
- d. E2
- e. radical

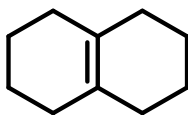
77. Which of the following substrates will give the fastest S_N1 reaction?



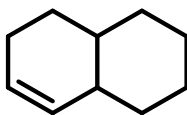
- a. i
- b. ii
- c. iii
- d. iv
- e. v

78. Arrange the following bicyclic alkenes in order of increasing stability (least stable to most stable).

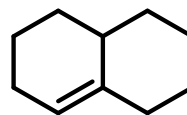
i.



ii.

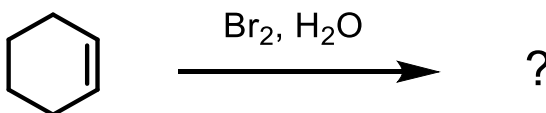


iii.



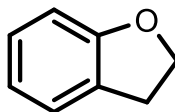
- a. $\text{iii} < \text{ii} < \text{i}$
- b. $\text{i} < \text{ii} < \text{iii}$
- c. $\text{i} < \text{iii} < \text{ii}$
- d. $\text{ii} < \text{iii} < \text{i}$
- e. $\text{ii} < \text{i} < \text{iii}$

79. The product of the following reaction can be best described as a...



- a. 1,2-dibromocyclohexane
- b. 1,2-dibromocyclohex-1-ene
- c. 2-bromocyclohexan-1-ol
- d. cyclohexane-1,2-diol
- e. cyclohexanol

80. How many resonance forms can be drawn for 2,3-dihydrobenzofuran (shown below)?



2,3-dihydrobenzofuran

- a. 3
- b. 4
- c. 5
- d. 6
- e. 7