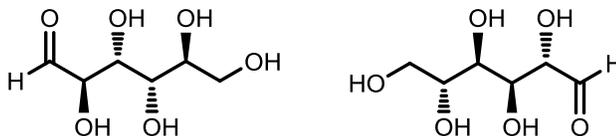


Chemistry Olympiad Problem Set #5, February 2022

81. What is the stereochemical relationship between the two molecules below?



a) enantiomers b) diastereomers c) epimers d) identical e) none of the above

82. In which of the following pure substances will hydrogen bonding be an important intermolecular force?

(1) Tribromomethane, CHBr_3

(3) *tert*-Butanol, $(\text{CH}_3)_3\text{COH}$

(2) Diethylamine, $\text{HN}(\text{CH}_2\text{CH}_3)_2$

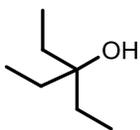
(4) Triphenylphosphine $(\text{C}_6\text{H}_5)_3\text{P}$

a) (3) and (4) only b) None of them c) All of them d) (2) and (3) only e) (3) only

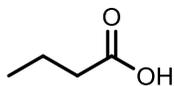
83. If 50 mg of phenacetin (mp 134 °C) is mixed with 50 mg of acetylsalicylic acid (mp 135 °C), the observed melting point of the resulting mixture will be:

- a) Sharp at 134-135 °C
- b) Sharp but slightly above 135 °C
- c) Sharp but slightly below 134 °C
- d) Over a broad range but ending at 134 °C
- e) Over a broad range but ending well below 134 °C

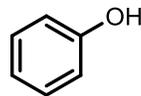
84. Rank the following compounds in order of decreasing acidity (most acidic to least acidic).



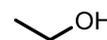
A



B



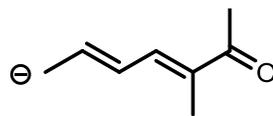
C



D

- a) $A > D > C > B$
- b) $B > D > C > A$
- c) $C > B > D > A$
- d) $B > C > D > A$
- e) $B > C > A > D$

85. How many resonance structures that contain only one formal charge are possible for the following anion?

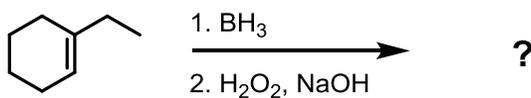


- a) 2 b) 3 c) 4 d) 5 e) 6

86. If (*E*)-6-methyloct-6-en-2-one was treated with ___(1)___, the product would contain ___(2)___.

- | | |
|---|-----------------|
| a) 1. a) LiAlH ₄ , Et ₂ O; b) H ₃ O ⁺ | 2. a 3° alcohol |
| b) 1. Br ₂ , CH ₂ Cl ₂ | 2. a halohydrin |
| c) 1. a) O ₃ b) Zn, HCl | 2. two ketones |
| d) 1. Br ₂ , H ₂ O | 2. a 2° alcohol |
| e) 1. a) Hg(OAc) ₂ , H ₂ O b) NaBH ₄ | 2. a 2° alcohol |

87. The product of the reaction shown below is:

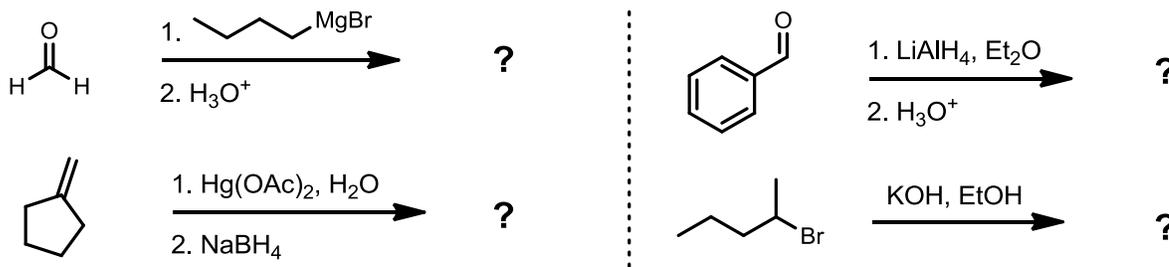


- a) + enantiomer
- b) + enantiomer
- c) + enantiomer
- d) + enantiomer
- e) + enantiomer

88. The reaction shown in question 87 is best described as:

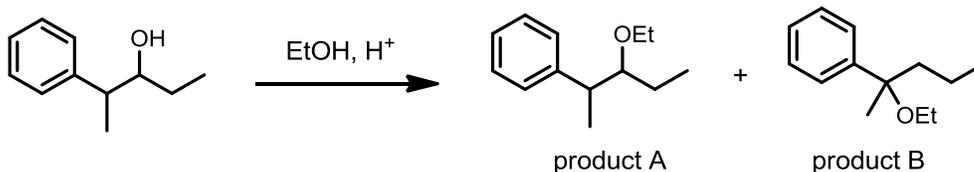
- a) stereospecific
 b) enantioselective
 c) regioselective
 d) both a and b
 e) both a and c

89. How many of the reactions below would produce a primary alcohol as the major product?



- a) 0 b) 1 c) 2 d) 3 e) 4

90. The following reaction produces a mixture of product A and B. Explain how each product is formed by identifying the key mechanistic steps:

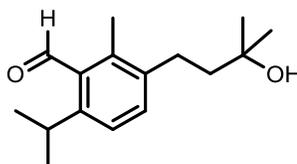


- (a) *Product A: S_N2, Product B: S_N2* where the initial carbocation undergoes a hydride shift
 (b) *Product A: S_N1, Product B: S_N2*
 (c) *Product A: S_N1, Product B: E1*
 (d) *Product A: S_N1, Product B: S_N1* where the initial carbocation undergoes a hydride shift
 (e) *Product A: S_N1, Product B: S_N1* where the initial carbocation undergoes an alkyl shift

91. Identify the main characteristic absorptions in the infrared (IR) spectrum of 7-hydroxy-3-methylheptanenitrile.

- a) 2260 cm⁻¹ (medium, sharp) and 1690 cm⁻¹ (strong, sharp)
 b) 3300 cm⁻¹ (strong, broad) and 1735 cm⁻¹ (strong, sharp)
 c) 3300 cm⁻¹ (strong, broad) and 1690 cm⁻¹ (strong, sharp)
 d) 3700 cm⁻¹ (strong, sharp) and 1735 cm⁻¹ (strong, sharp)
 e) 3300 cm⁻¹ (strong, broad) and 2260 cm⁻¹ (medium, sharp)

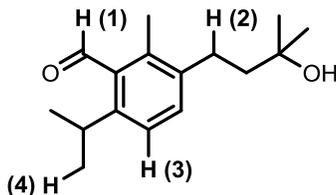
92. How many singlets would you expect in the ¹H NMR spectrum of the compound below?



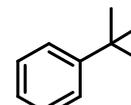
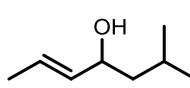
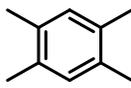
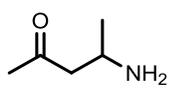
- a) 1 b) 2 c) 3 d) 4 e) 5

93. Rank the four highlighted hydrogen atoms on the structure in order of chemical shift (lowest to highest chemical shift):

- a) $1 < 3 < 2 < 4$
- b) $4 < 3 < 2 < 1$
- c) $4 < 2 < 1 < 3$
- d) $4 < 2 < 3 < 1$
- e) $2 < 4 < 3 < 1$

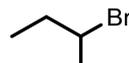
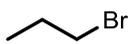
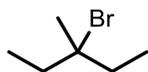


94. Order the following compounds according to the number of unique signals you would expect in the ^{13}C NMR spectra (least number of signals to most number of signals).



- a) $\text{I} < \text{II} < \text{IV} < \text{III}$
- b) $\text{II} < \text{I} < \text{IV} < \text{III}$
- c) $\text{II} < \text{I} < \text{III} < \text{IV}$
- d) $\text{I} < \text{III} < \text{IV} < \text{II}$
- e) $\text{I} < \text{IV} < \text{III} < \text{II}$

95. Rank the following compounds in order of their relative $\text{S}_{\text{N}}2$ reactivity (fastest to slowest):

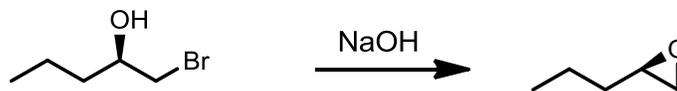


MeBr

IV

- a) $\text{I} > \text{III} > \text{II} > \text{IV}$
- b) $\text{IV} > \text{III} > \text{II} > \text{I}$
- c) $\text{IV} > \text{II} > \text{III} > \text{I}$
- d) $\text{III} > \text{I} > \text{II} > \text{IV}$
- e) $\text{IV} > \text{II} > \text{I} > \text{III}$

96. What type of reaction is the following transformation defined as?



- a) $\text{S}_{\text{N}}1$
- b) E2
- c) $\text{S}_{\text{N}}2$
- d) E1
- e) E1cb

