Chemistry Olympiad Problem Set #5, February 2021

81. The hydrobromination of prop-1-ene is an example of _____ reaction.

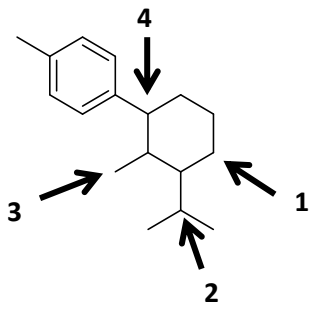
a) a nucleophilic substitution
b) an electrophilic addition
c) an electrophilic substitution
d) a nucleophilic addition
e) an elimination

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

(1) Dichloromethane, CH_2Cl_2
(2) Triethylamine, $N(CH_3)_3$
(3) Isopropanol, $(CH_3)_2CHOH$
(4) Diethyl ether, $CH_3CH_2OCH_2CH_3$

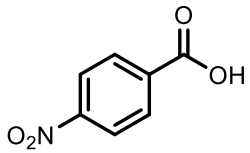
a) (1) and (2) only
b) (2) only
c) (3) and (4) only
d) (3) only
e) All four of them

83. On the structure shown below, four carbons have been highlighted. If a carbocation were to form on any of these highlighted carbons, their relative stability would vary greatly. Rank the carbocations in order of increasing stability (least stable to most stable):

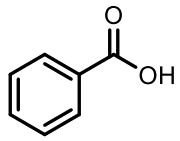


a) 2 < 4 < 3 < 1
b) 4 < 2 < 1 < 3
c) 3 < 1 < 4 < 2
d) 3 < 2 < 1 < 4
e) 3 < 1 < 2 < 4

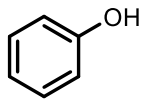
84. Rank the following compounds in order of decreasing acidity (most acidic to least acidic).



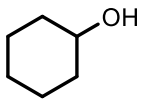
A



B



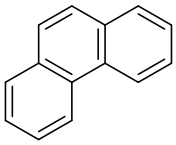
C

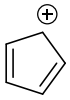


D

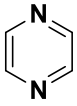
a) A > B > D > C
b) C > D > A > B
c) C > D > B > A
d) D > C > B > A
e) A > B > C > D

85. Which of the following compounds are anti-aromatic?


I



II

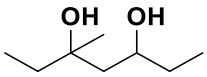


III

IV

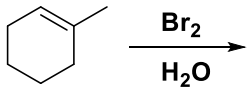
a) I, II only
b) I, IV only
c) II, IV only
d) II, III only
e) II, III, IV only

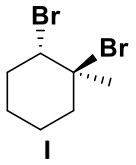
86. How many optically active stereoisomers are possible for the compound shown below?



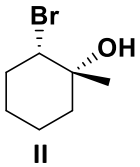
a) 0
b) 1
c) 2
d) 3
e) 4

87. The product of the below reaction is:

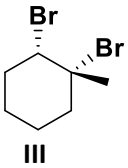




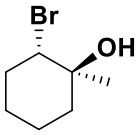
I



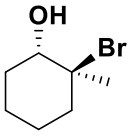
II



III



IV



V

a) I
b) II
c) III
d) IV
e) V

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

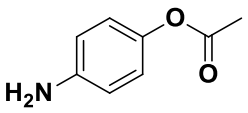
89. What reagents can be used to convert 1-propylcyclopent-1-ene into 1,2-dibromo-1-propylcyclopentane?

a) Br_2, H_2O
b) Br_2, EtOH
c) HBr, H_2O
d) Br_2, CH_2Cl_2
e) HBr, H_2O

90. Which of the following is true of the S_N2 reaction?

a) Bulkier substrates are best because they form the most stable carbocations.
b) The reaction is initiated by initial loss of the nucleophile.
c) Softer, less polarizable leaving groups are preferred.
d) Polar aprotic solvents afford the greatest reaction rates due to their ability to hydrogen bond to the nucleophile.
e) Sodium *tert*-butoxide is a poor nucleophile due to its steric hindrance.

The next three questions (#91 - 93) pertain to the structure of 4-aminoethyl acetate shown below.



91. How many degrees of unsaturation are there in the molecule?

a) 4
b) 5
c) 6
d) 7
e) 8

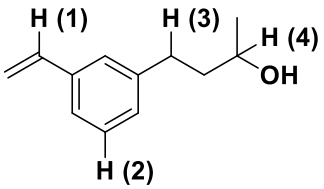
92. Identify the main characteristic absorptions in the infrared (IR) spectrum.

a) 2260 cm^{-1} (medium, sharp) and 1680 cm^{-1} (strong, sharp)
b) 3300 cm^{-1} (weak, broad) and 1735 cm^{-1} (strong,sharp)
c) 3300 cm^{-1} (weak, broad) and 2400 cm^{-1} (strong, sharp)
d) 3700 cm^{-1} (strong, sharp) and 1735 cm^{-1} (strong, sharp)
e) 3300 cm^{-1} (medium, sharp) and 2260 cm^{-1} (medium, sharp)

93. How many signals would you expect in the ^{13}C NMR spectrum of of 4-aminoethyl acetate?

a) 4
b) 5
c) 6
d) 7
e) 8

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

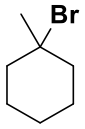


a) 3 < 4 < 1 < 2
b) 4 < 3 < 1 < 2
c) 3 < 1 < 4 < 2
d) 2 < 1 < 3 < 4
e) 4 < 3 < 1 < 2

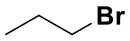
95. If the compound from #94 was treated to ozonolysis reaction conditions (1. O_3 , 2. Zn, HCl), which best describes the resultant product(s)?

a) Ketone only
b) Aldehyde only
c) Formaldehyde only
d) Aldehyde and formaldehyde
e) None of the above

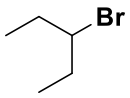
96. Rank the following compounds in order of their relative S_N1 reactivity (fastest to slowest)



I



II



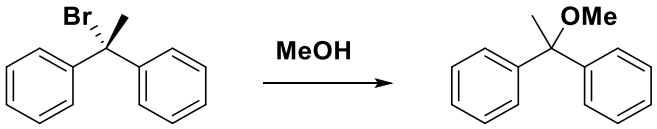
III

MeBr

IV

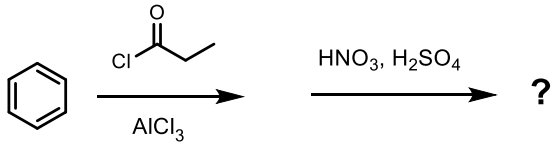
a) I > III > II > IV
b) II > III > I > IV
c) IV > II > III > I
d) III > I > II > IV
e) I > II > III > IV

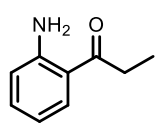
97. What type of reaction is the following transformation defined as?

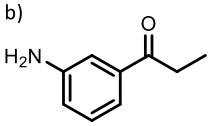


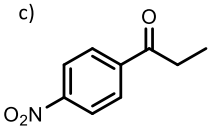
a) S_N1
b) E2
c) S_N2
d) E1
e) E1cb

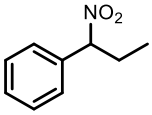
98. Predict the product of the following reaction scheme:

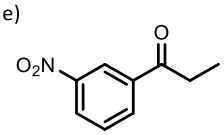


a) 

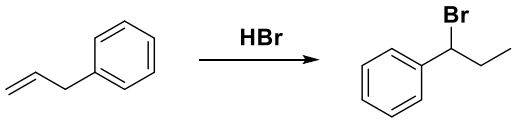
b) 

c) 

d) 

e) 

99. What is mechanistic step is involved in the reaction below?



a) S_N2
b) Radical formation
c) Alkyl shift
d) E1
e) Hydride shift

100. If (*R,E*)-3,4-dimethylhex-2-ene were hydrogenated on a catalytic surface of Pd/C, what best describes the resulting product(s)?

a) Diastereomers
b) Prochiral
c) Achiral
d) Enantiomers
e) Meso