Part III Test Bank
Chapter 1 Bonding and Isomerism

Valence, Bonding, and Lewis Structures

1.1. What is the most electropositive element?

***a.** Li **b.** Be **c.** B **d.** C **e.** N

1.2. Which of the following elements has 5 electrons in the valence (outer) shell?

a. C **b.** B **c.** S **d.** F ***e.** P

1.3. Which of the following would you expect to have ionic bonds?

***a.** MgF_2 **b.** CO **c.** ICl **d.** Br_2 **e.** NF_3

1.4. Which of the following would you expect to have polar covalent bonds?

a. MgF_2 **b.** N_2 **c.** F_2 ***d.** NF_3 **e.** NaF

1.5. Which molecule has nonpolar covalent bonds?

a. NO ***b.** N_2 **c.** BCl_3 **d.** HF **e.** CCl_4

1.6. The number of electrons in the valence shell of aluminum is:

a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

1.7. Which of the following elements is the most electronegative?

***a.** O **b.** S **c.** Se **d.** Te **e.** Po

1.8. If the Cl–Cl bond length is 1.98Å and the C–C bond length is 1.54Å, what would you expect the bond length of Cl–C to be?

a. 0.74Å **b.** 1.54Å ***c.** 1.76Å **d.** 1.98Å **e.** 3.52Å

1.9. Given the following electronegativity values, predict the most polar covalent bond below:

F	4.0
Cl	3.0
O	3.5
C	2.5
H	2.1

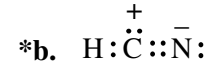
***a.** C–F **b.** C–Cl **c.** C–O **d.** C–H **e.** C–C

1.10. The most electronegative elements in the periodic table are generally found

a. toward the left in a horizontal row and toward the top in a column.
***b.** toward the right in a horizontal row and toward the top in a column.
c. toward the left in a horizontal row and toward the bottom in a column.
d. toward the right in a horizontal row and toward the bottom in a column.
e. distributed randomly throughout the table.

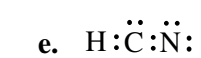
1.11. In which of the following electron-dot formulas is the Formal Charge incorrectly assigned?

a. 

***b.** 

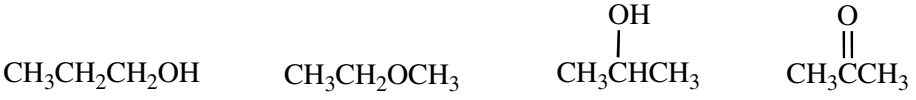
c. 

d.

e. 

Structural Isomers

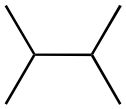
1.12. Which of the following molecules are structural isomers?

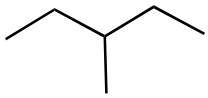


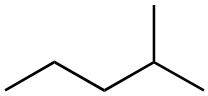
1 **2** **3** **4**

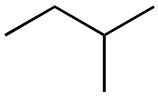
a. 1, 2, and 4 ***b.** 1, 2, and 3 **c.** 1, 3, and 4 **d.** 2, 3, and 4 **e.** 3 and 4

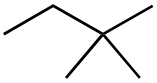
1.13. Which of the following abbreviated structural formulas is NOT an isomer of the others?

a. 

b. 

c. 

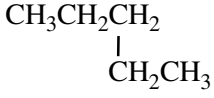
***d.** 

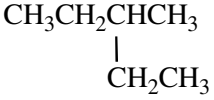
e. 

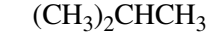
1.14. The number of possible acyclic hydrocarbons with the molecular formula C_4H_6 is

a. 2 **b.** 3 ***c.** 4 **d.** 5 **e.** 6

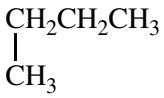
1.15. Which of the following structural formulas represents a structural isomer of $CH_3CH_2CH_2CH_2CH_3$?

a. 

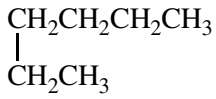
b. 

c. 

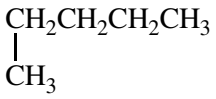
***d.** 

e. 

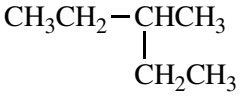
1.16. Which of the following molecules are structural isomers?



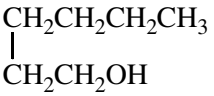
1



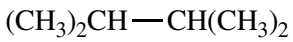
2



3



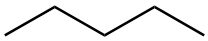
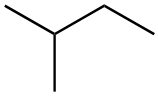
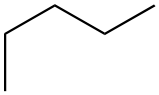
4

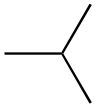
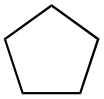


5

a. 1, 2 and 3 **b.** 1, 3 and 4 **c.** 2, 3 and 5
***d.** 1, 3 and 5 **e.** 2 and 3

1.17. Which of the following abbreviated structural formulas represents a structural isomer of $CH_3CH_2CH_2CH_2CH_3$?

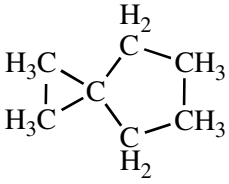
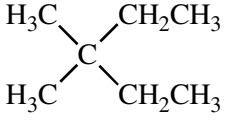
a.  ***b.**  **c.** 

d.  **e.** 

Structural Formulas

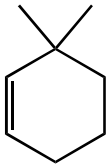
1.18. The structural formula for $(CH_3)_2C(CH_2CH_3)_2$ is

a. $CH_3CH_3CCH_2CH_3CH_2CH_3$ **b.** $CH_3CH_2CH_3{=\!=}CH_3CH_2CH_3$

c.  ***d.** 

e. C_7H_{16}

1.19. The structural formula



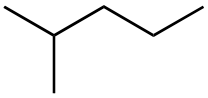
has the molecular formula

a. C_6H_{10} ***b.** C_8H_{14} **c.** C_8H_{16} **d.** C_8H_{18} **e.** C_8H_{20}

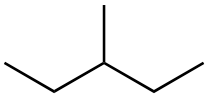
1.20. Which of the following structural formulas does *not* have the molecular formula C_6H_{14}?

a. 

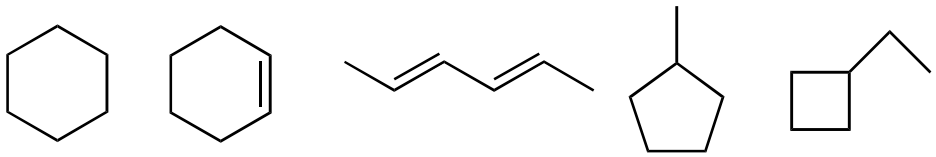
b. $(CH_3)_3CCH_2CH_3$

c. 

***d.** $(CH_3)_2CHCH_2CH_3$

e. 

1.21. Which of the following structural formulas has the molecular formula C_6H_{12}?

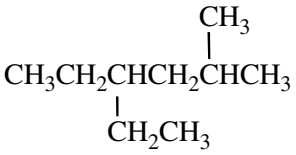


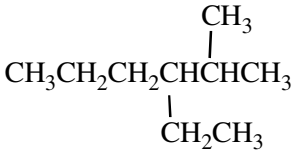
1 2 3 4 5

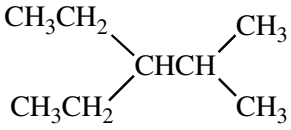
a. 2 and 3 **b.** 1 and 4 ***c.** 1, 4, and 5 **d.** 1 and 2 **e.** 4 and 5

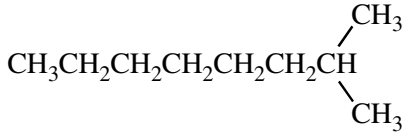
1.22. The structural formula for $(CH_3CH_2)_2CHCH_2CH(CH_3)_2$ is

a. C_9H_{20}

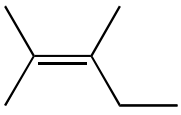
***b.** 

c. 

d. 

e. 

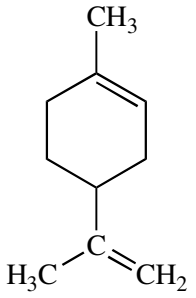
1.23. The structural formula



has the molecular formula

a. C_7H_{16} **b.** C_6H_{14} ***c.** C_7H_{14} **d.** C_6H_{12} **e.** C_7H_{12}

1.24. The structural formula



has the molecular formula

***a.** $C_{10}H_{16}$ **b.** C_9H_{18} **c.** $C_{10}H_{22}$ **d.** C_6H_{14} **e.** $C_{10}H_{18}$

Formal Charge, Resonance, and Curved-Arrow Formalism

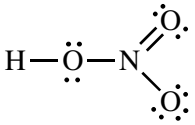
1.25. For carbon monoxide, :C≡O: , C has a formal charge of:

a. +1 ***b.** –1 **c.** 0 **d.** –2 **e.** +2

1.26. For carbon monoxide, :C≡O: , O has a formal charge of:

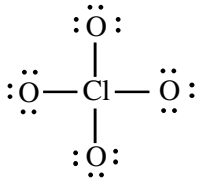
***a.** +1 **b.** –1 **c.** 0 **d.** –2 **e.** +2

1.27. What is the formal charge of N in HNO_3, as seen below?



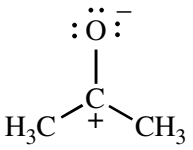
***a.** +1 **b.** +2 **c.** 0 **d.** –1 **e.** –2

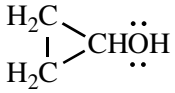
1.28. The formal charges in the perchlorate ion are

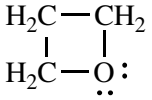


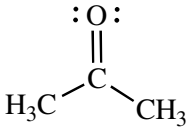
***a.** –1 on each O and +3 on the Cl.
b. 0 on each O and –1 on the Cl.
c. –1 on each O and +4 on the Cl.
d. –1/4 on each O and 0 on the Cl.
e. +1 on each O and –1 on the Cl.

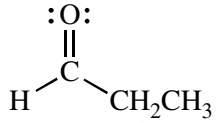
1.29. Which of the following structures is a resonance structure of

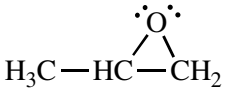


a. 

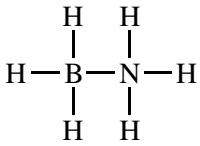
b. 

***c.** 

d. 

e. 

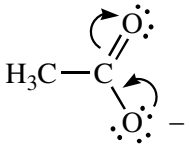
1.30. The formal charges in the complex



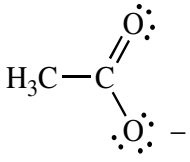
are

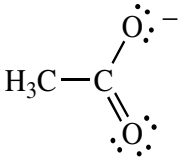
***a.** 0 on each H, +1 on N, and –1 on B.
b. +1 on each H, +1 on N, and –1 on B.
c. 0 on each H, –1 on N, and +1 on B.
d. 0 on each H, 0 on N, and 0 on B.
e. –1 on each H, +3 on N, and +3 on B.

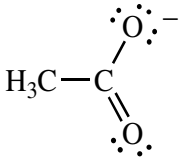
1.31. The curved arrows in the resonance structure for the acetate ion shown below

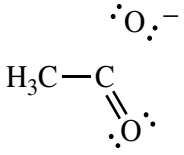


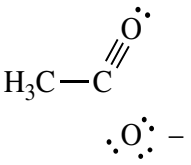
indicate the following alternative resonance structure for the acetate ion:

a. 

b. 

***c.** 

d. 

e. 

Electronic Structure and Molecular Geometry

1.32. What is the percent *s* character in an sp^3 hybridized orbital?

***a.** 25% **b.** 33% **c.** 50% **d.** 67% **e.** 75%

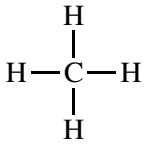
1.33. The maximum number of electrons that a molecular orbital can contain is:

a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** 5

1.34. The approximate H–C–H bond angle in methane is:

a. 60° **b.** 90° ***c.** 109.5° **d.** 120° **e.** 180°

1.35. The Lewis structure of methane is

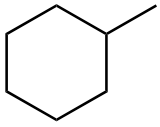


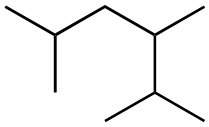
The approximate H–C–H bond angle in methane is

a. 60° **b.** 90° ***c.** 109.5° **d.** 120° **e.** 180°

Classification of Organic Compounds

1.36. Which of the following molecules is carbocyclic?

a. $CH_3CH_2CH_3$ ***b.**  **c.** CH_3CHCH_3 with CH_3 below

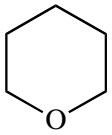
d.  **e.** $CH_3OCH_2CH_3$

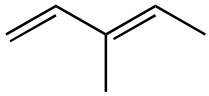
1.37. Which of the following molecules contain the same functional group?

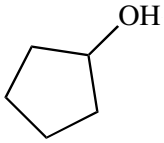
CH_3OH	CH_3OCH_3	CH_3CH_2OH	$CH_3CH(OH)CH_3$
1	**2**	**3**	**4**

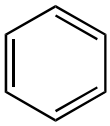
a. 1, 2 and 3 ***b.** 1, 3 and 4 **c.** 1 and 2 **d.** 2 and 4 **e.** 3 and 4

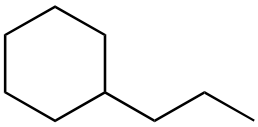
1.38. Which of the following molecules is acyclic?

a. 

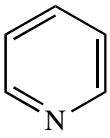
***b.** 

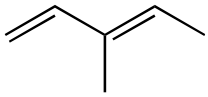
c. 

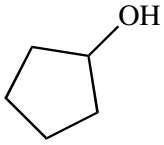
d. 

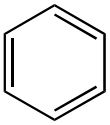
e. 

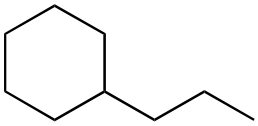
1.39. Which of the following molecules is heterocyclic?

***a.** 

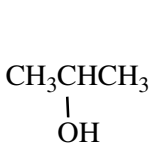
b. 

c. 

d. 

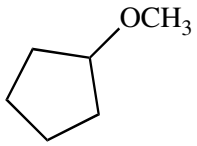
e. 

1.40. Which of the following molecules contain the same functional group?

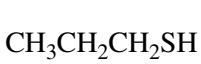


1

2



3



4

a. 1, 2 and 3 **b.** 1, 2 and 4 **c.** 2 and 4
***d.** 1 and 2 **e.** 1 and 3

Chapter 2
Alkanes and Cycloalkanes; Conformational and Geometric Isomerism

Alkane Nomenclature and Structural Formulas

2.1. What is the molecular formula of an alkane that has fourteen carbon atoms?

a. $C_{14}H_{28}$ ***b.** $C_{14}H_{30}$ **c.** $C_{14}H_{32}$ **d.** $C_{14}H_{34}$ **e.** $C_{14}H_{26}$

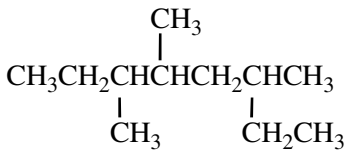
2.2. What is the molecular formula of a cycloalkane that has five carbon atoms?

***a.** C_5H_{10} **b.** C_5H_{12} **c.** C_5H_{14} **d.** C_5H_8 **e.** C_5H_5

2.3. What is the name of the alkane that has two carbon atoms?

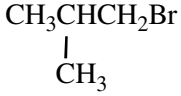
a. methane ***b.** ethane **c.** propane **d.** butane **e.** isobutane

2.4. The correct IUPAC name for the following molecule is:



a. 6-ethyl-3,4,-dimethylheptane
b. 2-ethyl-4,5-dimethylheptane
***c.** 3,4,6-trimethyloctane
d. 3,5,6-trimethyloctane
e. none of these

2.5. What is the common name for the following molecule?



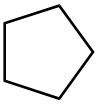
***a.** isobutyl bromide **b.** *tert*-butyl bromide **c.** butyl bromide
d. *sec*-butyl bromide **e.** bromo-*sec*-butane

2.6. The name of the alkyl group that contains two carbons is:

a. methyl ***b.** ethyl **c.** propyl
d. isopropyl **e.** none of these

2.7. Which of the following structures is 2-methylpentane?

a. $CH_3CH_2CH_2CH_2CH_3$ ***b.** $CH_3CH(CH_3)CH_2CH_2CH_3$ **c.** $CH_3C(CH_3)_2CH_3$

d.  **e.** $CH_3CH_2CH(CH_3)CH_3$

2.8. The name of the alkyl group below is:

$CH_3CH(CH_3)-$

a. ethyl **b.** propyl ***c.** isopropyl **d.** butyl **e.** isobutyl

2.9. What is the IUPAC name for the following compound?

$CH_3CH_2CH(Br)CH(CH_3)CH_3$

a. isohexyl bromide
b. 3-bromo-4-methylpentane
c. 1-bromopropylpropane
***d.** 3-bromo-2-methylpentane
e. 2-methyl-3-bromopentane

2.10. The IUPAC name for the following molecule is:

$CH_3CH_2CHClC(CH_3)_3$

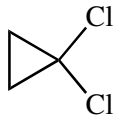
a. 3-chloroheptane
b. 2-chloro-1,1,1-trimethylbutane
c. *t*-butylpropyl chloride
d. 3-chloro-1-dimethylpentane
***e.** 3-chloro-2,2-dimethylpentane

2.11. Which of the following structures is *tert*-butyl iodide?

a. $CH_3CH_2CH_2CH_2I$ **b.** $CH_3CH(CH_3)CH_2CH_2I$ **c.** $CH_3CH(I)CH_2CH_3$

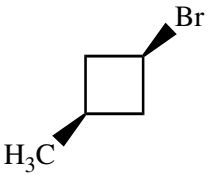
***d.** $CH_3C(I)(CH_3)CH_3$ **e.** $CH_3CH(I)CH_3$

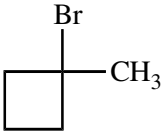
2.12. What is a correct name for the following molecule?

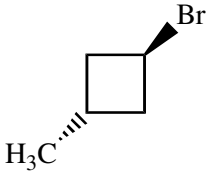


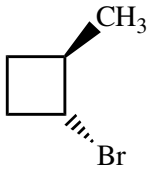
a. 2,2-dichlorocyclopropane
b. 1,1-dichlorocyclopentane
c. 1,1-dichloropropane
d. *trans*-1,1-dichlorocyclopropane
***e.** 1,1-dichlorocyclopropane

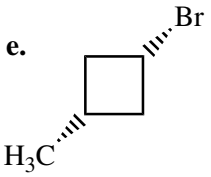
2.13. *Trans*-1-bromo-3-methylcyclobutane is represented by which structure below?

a.


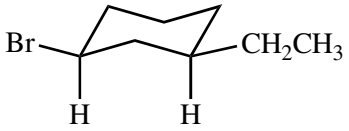
b.


***c.**


d.


e.


2.14. What is the correct name for the following cycloalkane?

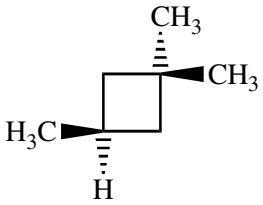


a. bromoethylcyclohexane
b. *trans*-1-ethyl-3-bromocyclohexane
c. *cis*-3-bromo-1-ethylhexane
d. 1-bromo-3-ethylcyclohexane
***e.** *cis*-1-bromo-3-ethylcyclohexane

2.15. The correct IUPAC name for $(CH_3)_2CHCH(CH_3)(CH_2)_3CH(CH_3)_2$ is

a. diisopropylpentane.
b. 1,1,2,6,6-pentamethylhexane.
c. 2,5-diisopropylpentane.
***d.** 2,3,7-trimethyloctane.
e. 1,4-diisopropylpentane.

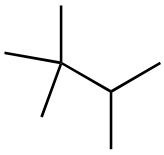
2.16. The correct IUPAC name for

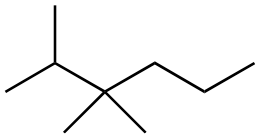


is

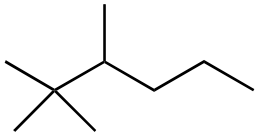
a. 1,3,3-trimethylcyclobutane.
b. *cis*-1,3,3-trimethylcyclobutane.
c. *trans*-1,3,3-trimethylcyclobutane.
***d.** 1,1,3-trimethylcyclobutane.
e. 2,2,4-trimethylcyclobutane.

2.17. The structural formula for 2,2,3-trimethylhexane is

a. 

b. 

c. $(CH_3)_2CCH_2CH_3$ with CH_3 below

***d.** 

e. $(CH_3)_3CCHCH_3$ with CH_3 below

Alkane Properties

2.18. Which of the following would exhibit hydrogen bonding?

a. CH_3Cl ***b.** CH_3OH **c.** CH_4 **d.** CH_2Cl_2 **e.** CH_3CH_3

2.19. Which of the following alkanes would have the highest boiling point?

a. pentane **b.** isopentane **c.** neopentane
***d.** hexane **e.** isohexane

2.20. What statement does NOT apply to the boiling points of alkanes?

a. The boiling point increases as the length of the carbon chain increases.
b. Straight chain alkanes have a higher boiling point than their branched isomers.
c. Because they are nonpolar, alkanes have lower boiling points than other organic compounds of similar molar mass.
d. The boiling points are affected by Van der Waals attractions.
***e.** The boiling points are influenced by hydrogen bonding.

2.21. Which cycloalkane has the highest boiling point?

a. cyclopropane **b.** cyclobutane **c.** cyclopentane
d. cyclohexane ***e.** cyclooctane

2.22. The boiling points of normal alkanes

a. rise as the length of the carbon chain increases.
b. rise as the length of the carbon chain decreases.
c. are higher than the boiling points of branched alkanes with the same molecular formula.
***d.** a and c
e. b and c

Conformations of Alkanes

2.23. The most stable conformation of propane is:

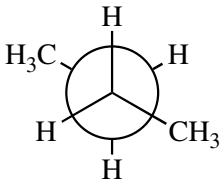
***a.** staggered **b.** chair **c.** planar **d.** eclipsed **e.** boat

2.24 The least stable conformation of propane is:

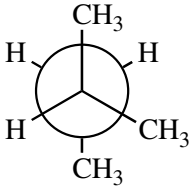
a. staggered **b.** chair **c.** planar ***d.** eclipsed **e.** boat

2.25. The preferred conformation of butane is given by which of the following Newman projection formulas?

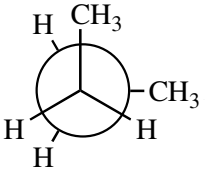
***a.**



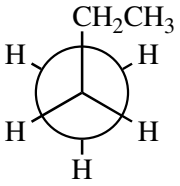
b.



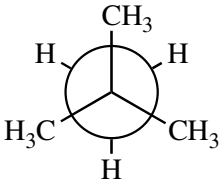
c.



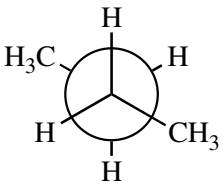
d.

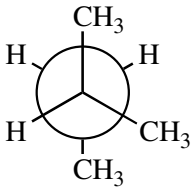


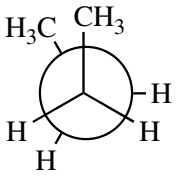
e.

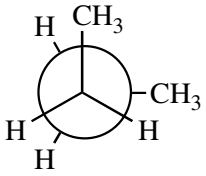


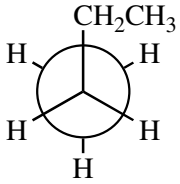
2.26. The least stable conformation of butane is given by which of the following Newman projections?

a. 

b. 

***c.** 

d. 

e. 

Conformations of Cycloalkanes

2.27. The preferred conformation of *cis*-3-*tert*-butyl-1-methylcyclohexane is the one in which:

a. the *t*-butyl group is axial and the methyl group is equatorial
b. both groups are axial
***c.** both groups are equatorial
d. the methyl group is axial and the *t*-butyl group is equatorial
e. molecule exists in a boat conformation

2.28. The bond angle of a normal, tetrahedral, sp^3 hybridized carbon is 109.5°. What is the C–C–C bond angle of cyclopropane?

***a.** 60° **b.** 90° **c.** 109.5° **d.** 120° **e.** 180°

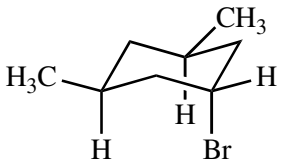
2.29. For the most stable conformation of *trans*-1,2-dimethylcyclohexane:

a. both methyls will occupy the axial position
***b.** both methyls will occupy the equatorial position
c. one methyl will occupy the axial position and the other an equatorial position
d. more than one answer is correct

2.30. Which of the following pairs are examples of conformational isomerism?

***a.** chair and boat forms of cyclohexane
b. 1-iodopropane and 2-iodopropane
c. *sec*-butyl chloride and butyl iodide
d. *cis* and *trans*-1,2-dimethylcyclohexane
e. all of these

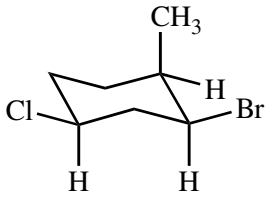
2.31. Consider this chair conformation:



When the ring flips,

a. the bromine becomes axial and the methyls become equatorial.
b. all three substituents become equatorial.
***c.** the bromine becomes equatorial and the methyls become axial.
d. the ring opens up.
e. one methyl becomes axial, one becomes equatorial, and the bromine becomes equatorial.

2.32. Consider this chair conformation:



***a.** The methyl and bromine are *cis* and the chlorine and bromine are *cis*.
b. The methyl and bromine are *trans* and the chlorine and bromine are *cis*.
c. The methyl and chlorine are *trans* and the methyl and bromine are *cis*.
d. The methyl and chlorine are *trans* and the methyl and bromine are *trans*.
e. The methyl and chlorine are *trans* and the bromine and chlorine are *cis*.

2.33. Cycloalkanes with _____ or more carbons in the ring are nonplanar.

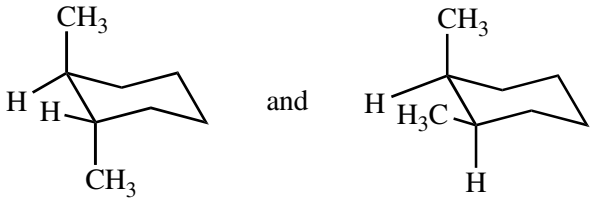
a. 2 **b.** 3 ***c.** 4 **d.** 5 **e.** 6

Isomerism

2.34. 1-Bromopropane and 2-bromopropane are

***a.** constitutional isomers.
b. homologs.
c. configurational isomers.
d. conformational isomers.
e. stereoisomers.

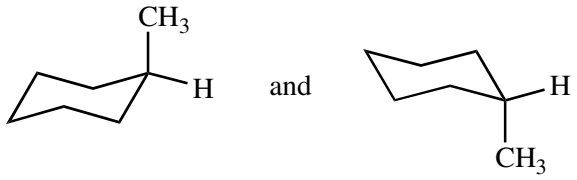
2.35. The compounds represented by the structures



are

a. structural isomers. **b.** identical. ***c.** *cis-trans* isomers.
d. conformers. **e.** constitutional isomers.

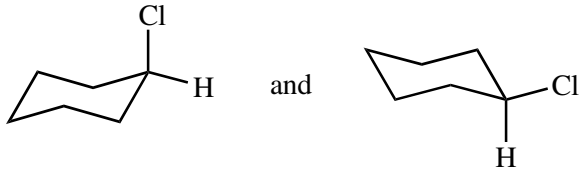
2.36. The compounds represented by the structures



are

a. structural isomers. ***b.** identical. **c.** *cis-trans* isomers.
d. conformers. **e.** constitutional isomers.

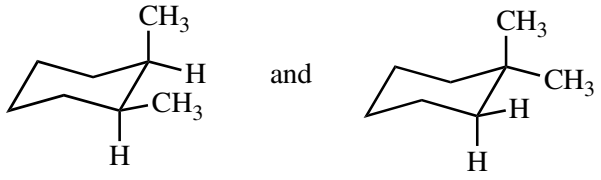
2.37. The compounds represented by the structures



are

a. structural isomers. **b.** identical. **c.** *cis-trans* isomers.
***d.** conformers. **e.** constitutional isomers.

2.38. The compounds represented by the structures



are

***a.** structural isomers. **b.** identical. **c.** *cis-trans* isomers.
d. conformers. **e.** stereoisomers.

Reactions of Alkanes

2.39. In the chlorination of methane, the propagation steps involve forming:

a. H radicals **b.** methyl radicals **c.** chlorine radicals
d. a, b, and c ***e.** b and c

2.40. How many monobromo products can be obtained from the bromination of cyclopentane?

***a.** 1 **b.** 2 **c.** 3 **d.** 4 **e.** 5

2.41. How many isomeric dichloro products can be obtained from the chlorination of cyclopropane?

a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

2.42. The number of possible monobromination products, including *cis-trans* isomers, of methylcyclopentane is

a. 2 **b.** 3 **c.** 4 **d.** 5 ***e.** 6

2.43. The number of possible dibromination products of 2-methylpropane is

a. 2 ***b.** 3 **c.** 4 **d.** 5 **e.**

2.44. The number of possible dichlorination products of propane is

a. 2 **b.** 3 ***c.** 4 **d.** 5 **e.** 6

Chapter 3
Alkenes and Alkynes

Alkenes and Alkynes: Nomenclature and Structure

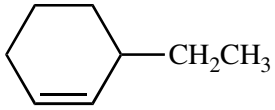
3.1. Which of the following dienes can be classified as conjugated?

a. $CH_3CH=C=CH_2$ ***b.** $CH_3CH=CHCH=CH_2$
c. $CH_2=CHCH_2CH=CH_2$ **d.** $CH_3CH=CHCH_2CH_2CH=CH_2$
e. $CH_2=C=CH_2$

3.2. Which of the following molecular formulas could not represent an alkene?

a. C_5H_{10} **b.** C_7H_{14} **c.** $C_{10}H_{20}$ ***d.** $C_{27}H_{56}$ **e.** $C_{31}H_{62}$

3.3. What is the correct name for the following molecule?

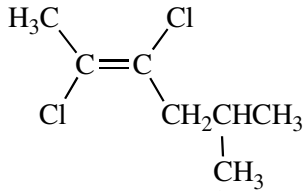


a. 1-ethylcyclohexene **b.** 2-ethylcyclohexene ***c.** 3-ethylcyclohexene
d. cyclohexylethane **e.** 1-ethyl-3-cyclohexene

3.4. Which of the following compounds can exhibit *cis*/*trans* isomerism?

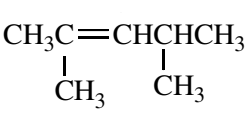
a. 1-pentene ***b.** 2-pentene **c.** 2-methyl-2-pentene
d. 3-methyl-1-pentene **e.** 1-hexene

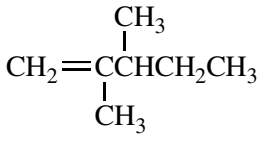
3.5. The correct IUPAC name for the following molecule is:

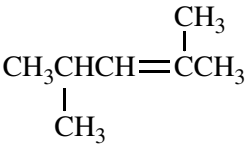


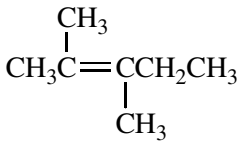
***a.** *trans*-2,3-dichloro-5-methyl-2-hexene
b. *trans*-2,3-dichloro-5-methyl-3-hexene
c. *cis*-2,3-dichloro-5-methyl-3-hexene
d. *trans*-4,5-dichloro-2-methyl-4-hexene
e. *cis*-4,5-dichloro-2-methyl-4-hexene

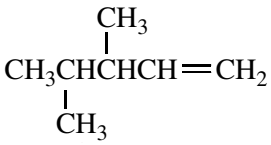
3.6. What is the correct structure for 2,3-dimethyl-2-pentene?

a. 

b. 

c. 

***d.** 

e. 

3.7. The correct structure for allyl bromide is:

***a.** $CH_2{=}CHCH_2Br$ **b.** $CH_2{=}CHBr$ **c.** $BrCH{=}CHBr$

d. $BrCH{=}CHCH_3$ **e.** $CH_2{=}CHCHBr_2$

3.8. Which of the following molecules is 4-methyl-2-hexyne?

***a.** $CH_3C{\equiv}CCHCH_2CH_3$ (with CH_3 branch)

b. $CH_3CH_2C{\equiv}CCH_2CH_3$

c. $CH_3CHCH_2C{\equiv}CCH_3$ (with CH_3 branch)

d. $CH_3C{\equiv}CCH_2CHCH_3$ (with CH_3 branch)

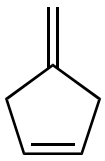
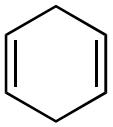
e. $CH_3CHC{\equiv}CCH_2CH_3$ (with CH_3 branch)

3.9. The correct name of the molecule below is:

$HC{\equiv}CCH_2CH_2CHCH_2CH{=}CH_2$ (with CH_3 branch)

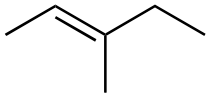
a. 5-methyl-7-octen-1-yne
***b.** 4-methyl-1-octen-7-yne
c. 4-methyl-1-octyn-7-ene
d. 5-methyl-1-octen-7-yne
e. none of these is correct

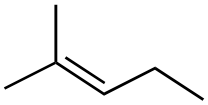
3.10. The multiple bonds in the following compounds are conjugated:

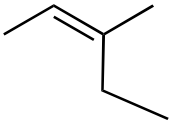
1. $CH_2{=}C{=}CH_2$
2. $CH_2{=}C(CH_3)-C(CH_3){=}CH_2$
3. $CH_2{=}CH-CH{=}O$
4. 
5. $CH_3-C{\equiv}C-CH{=}CH_2$
6. 

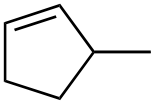
***a.** 2, 3, and 5 **b.** 4 and 6 **c.** only 1 **d.** 2 and 3 **e.** 2 and 5

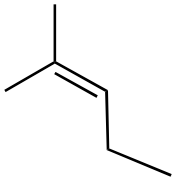
3.11. The structure of (*Z*)-3-methyl-2-pentene is

a. 

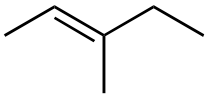
b. 

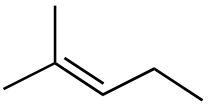
***c.** 

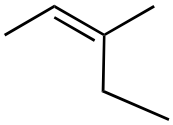
d. 

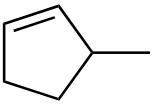
e. 

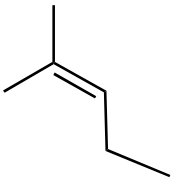
3.12. The structure of (*E*)-3-methyl-2-pentene is

***a.** 

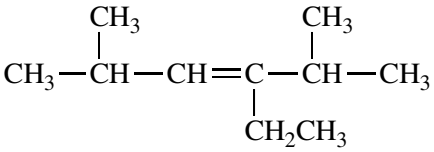
b. 

c. 

d. 

e. 

3.13. The correct name for



is

a. 2-methyl-4-isopropyl-3-hexene.
***b.** 3-ethyl-2,5-dimethyl-3-hexene.
c. 2,5-dimethyl-4-ethyl-3-hexene.
d. 1-ethyl-1,2-diisopropylethene.
e. 1,2-diisopropyl-1-butene.

3.14. The double bond in ethene is made up of

a. a pi bond and a sigma bond formed by lateral overlap of two *p* orbitals.
b. a sigma bond formed by overlap of two *s* orbitals and a pi bond formed by lateral overlap of two *p* orbitals.
c. a pi bond formed by end-on overlap of two sp^2 orbitals and a sigma bond formed by overlap of two *s* orbitals.
***d.** a sigma bond formed by end-on overlap of two sp^2 orbitals and a pi bond formed by lateral overlap of two *p* orbitals.
e. a pi bond formed by lateral overlap of two sp^2 orbitals and a sigma bond formed by end-on overlap of two sp^2 orbitals.

3.15. The triple bond in ethyne is made up of

a. two pi bonds and a sigma bond, each formed by a lateral overlap of two *p* orbitals.
b. a sigma bond formed by overlap of two *s* orbitals and two pi bonds, each formed by lateral overlap of two *p* orbitals.
c. a sigma bond formed by end-on overlap of two sp^2 orbitals and a pi bond formed by lateral overlap of two *p* orbitals.
***d.** two pi bonds, each formed by lateral overlap of two *p* orbitals, and a sigma bond formed by end-on overlap of two *sp* orbitals.
e. two pi bonds, each formed by end-on overlap of two *p* orbitals, and a sigma bond formed by lateral overlap of two *sp* orbitals.

Properties of Alkenes and Alkynes

3.16. Which of the following statements is FALSE relative to alkenes?

a. the C of the carbon-carbon double bond is sp^2 hybridized
b. the bond angles are approximately 120° around the carbon-carbon double bond
c. there is the possibility of *cis/trans* isomerism
***d.** they are less reactive than alkanes
e. the bond length of the carbon-carbon double bond is shorter than that of the carbon-carbon single bond

3.17. Which of the following hydrocarbons will be the most acidic?

a. pentane **b.** ethene ***c.** acetylene
d. isobutane **e.** propylene

3.18. Which of the following statements are true about alkynes?

a. they are more acidic than other hydrocarbons
b. the bond angle around the carbon-carbon triple bond is 180°
c. the carbon-carbon triple bond is shorter than the carbon-carbon double bond
***d.** all of the above are true
e. none of the above are true

3.19. What is the percent *s* character in an sp^2 hybrid orbital?

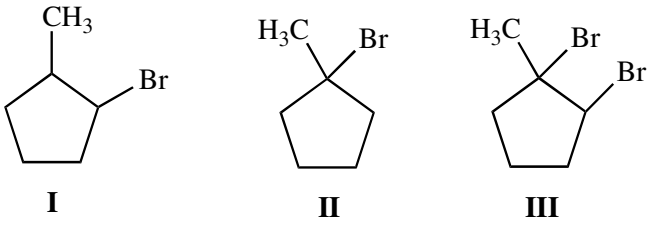
a. 25% ***b.** 33% **c.** 50% **d.** 67% **e.** 75%

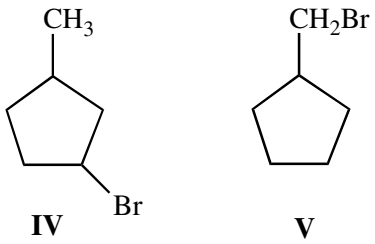
3.20. What is the percent *s* character in an *sp* hybrid orbital?

a. 25% **b.** 33% ***c.** 50% **d.** 67% **e.** 75%

Reactions of Alkenes

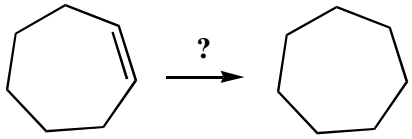
3.21. What would be the *major* product of the following reaction?





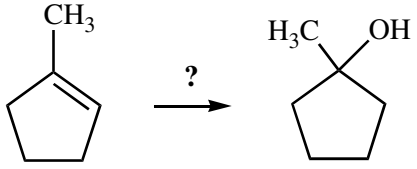
a. I ***b.** II **c.** III **d.** IV **e.** V

3.22. Select the necessary reagent(s) to convert cycloheptene to cycloheptane.



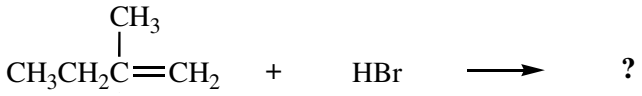
***a.** H_2 and Ni **b.** H_2O **c.** H_2SO_4 and heat
d. Zn and H^+ **e.** KOH in alcohol and heat

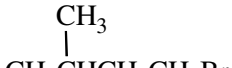
3.23. Select the necessary reagents to convert methylcyclopentene to 1-methylcyclopentanol.

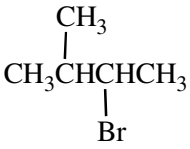


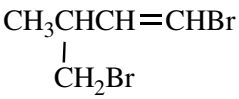
***a.** H_2O and H_2SO_4 **b.** Zn, H_2O **c.** BH_3, then H_2O_2 and ^-OH
d. O_3, then Zn, H^+ **e.** KOH in alcohol and heat

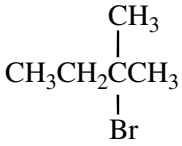
3.24. What is the product for the reaction below?



a. 

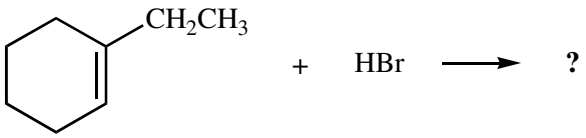
b. 

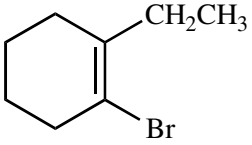
c. 

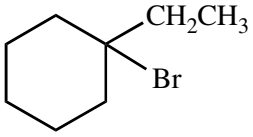
***d.** 

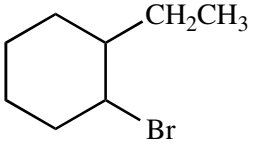
e. none of these

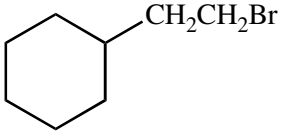
3.25. What is the product for the reaction below?

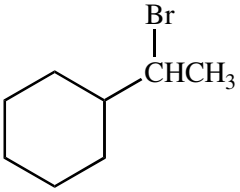


a. 

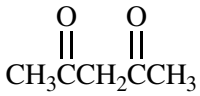
***b.** 

c. 

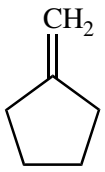
d. 

e. 

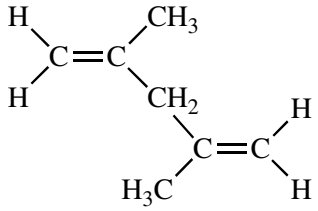
3.26. Upon ozonolysis and treatment with Zn in water, compound A yielded two moles of formaldehyde, HCHO, and 1 mole of the following molecule:



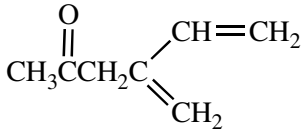
What is the structure of A?



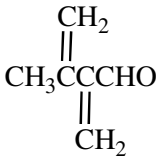
I



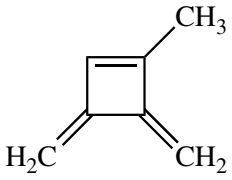
II



III



IV

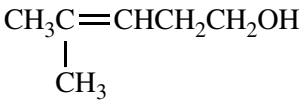


V

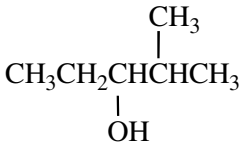
a. I ***b.** II **c.** III **d.** IV **e.** V

3.27. What is observed when water, in the presence of sulfuric acid, is added to 2-methyl-2-pentene?

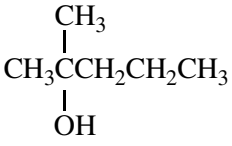
a.



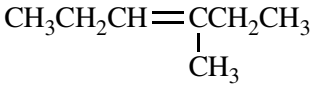
b.



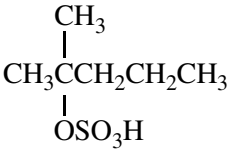
***c.**



d.



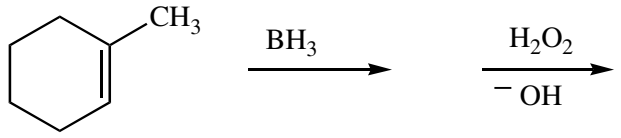
e.



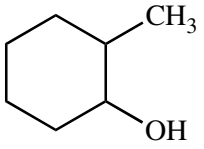
3.28. The products obtained by the acid-catalyzed hydration of methylcyclopentene and methylenecyclopentane are

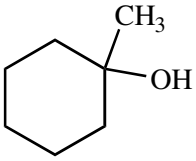
***a.** identical. **b.** regioisomers. **c.** *cis-trans* isomers.
d. constitutional isomers. **e.** conformers.

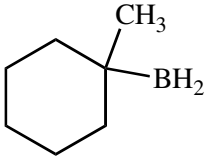
3.29. The product of the reaction sequence

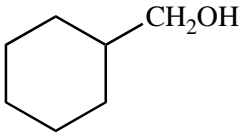


is

***a.** 

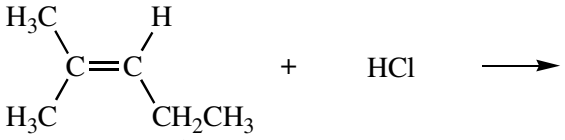
b. 

c. 

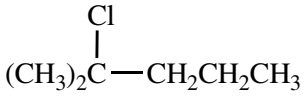
d. 

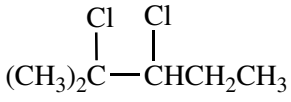
e. none of the above

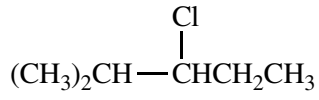
3.30. The product of the reaction

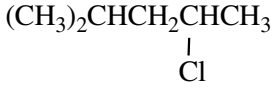


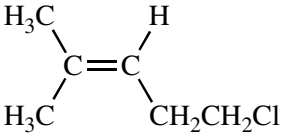
is

***a.** 

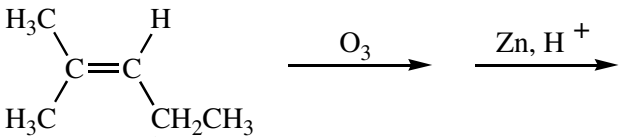
b. 

c. 

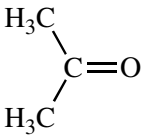
d. 

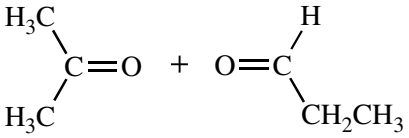
e. 

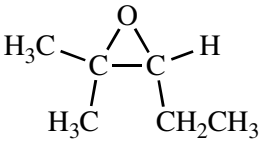
3.31. The products of the following reaction sequence

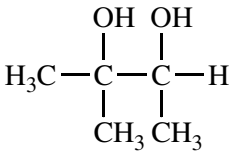


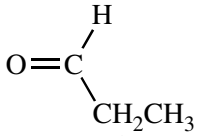
are

a. 2 

***b.** 

c. 

d. 

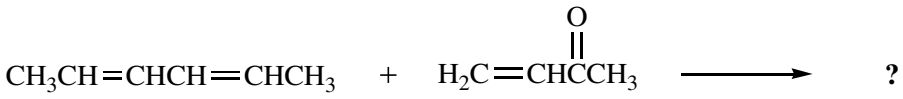
e. 2 

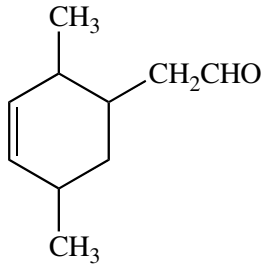
Reactions of Conjugated Dienes

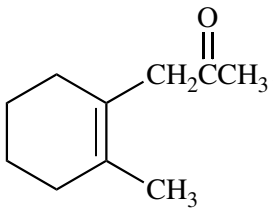
3.32. What product(s) will be observed by the addition of one molar equivalent of Br_2 to 1,3-cyclohexadiene?

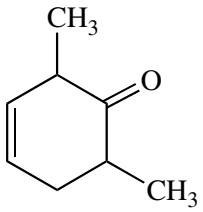
a. 1,2-dibromocyclohexene
b. 3,4-dibromocyclohexene
c. 1,3-dibromocyclohexene
d. 3,6-dibromocyclohexene
***e.** both b and d

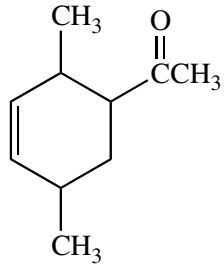
3.33. The Diels-Alder reaction is very important in the synthesis of six-membered rings. What six-membered ring is produced with the following reaction?

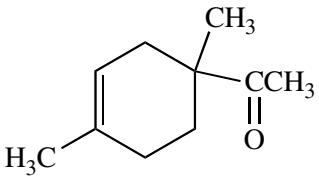


a.


b.


c.


***d.**


e.


3.34. The product of addition of two moles of HBr to 1,4-pentadiene is

a. 2,2-dibromopentane. ***b.** 2,4-dibromopentane.
c. 1,5-dibromopentane. **d.** 3,3-dibromopentane.
e. 1,4-dibromopentane.

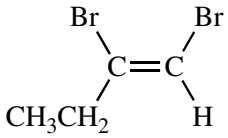
3.35. The products obtained by adding 1 mole of HBr to 2,4-hexadiene are

a. 4-bromo-2-hexene and 5-bromo-2-hexene.
b. 3-bromo-2-hexene and 4-bromo-2-hexene.
c. 4-bromo-2-hexene and 2-bromo-4-hexene.
d. 2-bromo-3-hexene and 3-bromo-2-hexene.
***e.** 2-bromo-3-hexene and 4-bromo-2-hexene.

Reactions of Alkynes

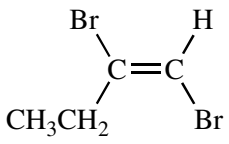
3.36. The product of the reaction

is

a.


b. $CH_3CH_2CBr_2CH_3$

***c.** $CH_3CH_2CBr_2CHBr_2$

d.


e. $CH_3CH_2CHBrCH_2Br$

3.37. What type of compound is prepared by adding water to acetylene (C_2H_2) in the presence of sulfuric acid and mercuric sulfate?

***a.** aldehyde **b.** ketone **c.** carboxylic acid
d. ester **e.** ether

3.38. The product of the reaction

$$CH_3CH_2C{\equiv}CH \xrightarrow[\text{in liquid } NH_3]{NaNH_2}$$

is

a. $CH_3CH_2C(Na){=}CH_2$

***b.** $CH_3CH_2C{\equiv}C:^{-}\ Na^{+}$

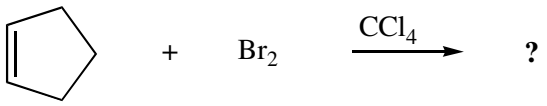
c. $CH_3CH_2C(NH_2){=}CH_2$

d. $CH_3CH_2CH{=}CHNH_2$

e. $CH_3CH_2C(Na){=}CHNH_2$

Reactions and Nomenclature

3.39. What is the name of the product formed from the following reaction?



a. bromocyclopentane
b. 1,1-dibromocyclopentane
***c.** 1,2-dibromocyclopentane
d. 2,2-dibromocyclopentane
e. 1,1-dibromocyclopentene

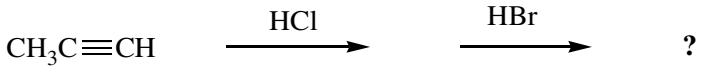
3.40. Addition of H_2 to 2-butyne in the presence of the Lindlar's catalyst will produce:

a. butane **b.** 1-butene
***c.** *cis*-2-butene **d.** *trans*-2-butene
e. isobutylene

3.41. What alkene is required to make 3-methyl-1-butanol using the hydroboration-oxidation reaction?

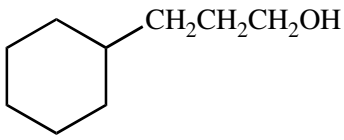
a. 1-butene **b.** 2-butene
***c.** 3-methyl-1-butene **d.** 2-methyl-2-butene
e. 2-methyl-1-butene

3.42. What is the final product of adding 1 mole of each reactant in the following sequence?



a. propyl chloride
b. propyl bromide
c. 1-bromo-2-chloropropane
***d.** 2-bromo-2-chloropropane
e. 2,2-dibromopropane

3.43. Which of the following alkenes is needed to prepare 3-cyclohexyl-1-propanol via a hydroboration-oxidation reaction?



3-cyclohexyl-1-propanol

a. cyclohexene
b. vinyl cyclohexane
***c.** allyl cyclohexane
d. propyl cyclohexene
e. 1- octene

3.44. Upon ozonolysis which alkene will give only acetone, $(CH_3)_2C{=}O$?

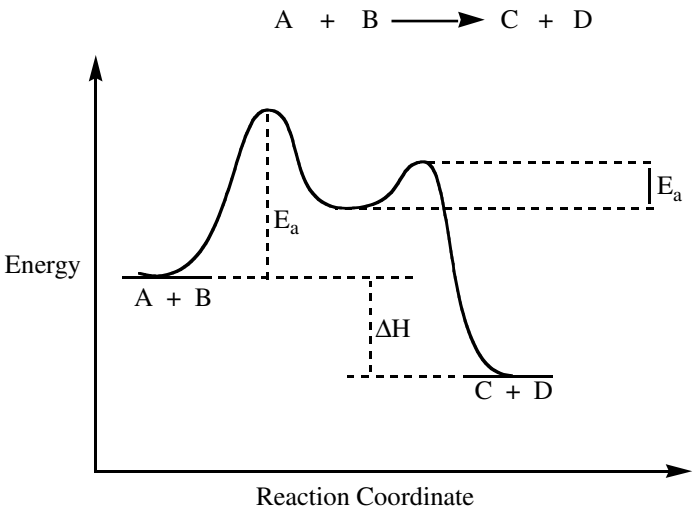
***a.** 2,3-dimethyl-2-butene
b. 2,2-dimethyl-2-butene
c. 3-hexene
d. 2-methyl-2-pentene
e. 2-methyl-3-hexene

3.45. What is the name of the alkene produced by treating 2-butyne with 1 mole of Br_2?

a. 1,2-dibromo-1-butene
b. 2,3-dibromo-1-butene
***c.** *trans*-2,3-dibromo-2-butene
d. 2,3-dibromo-1-butene
e. *cis*-1,4-dibromo-2-butene

Reaction Equilibrium and Reaction Rates

3.46. Examine the following reaction energy diagram for the reaction



Which of the following statements are true?

1. The reaction is exothermic.
2. The reaction occurs in one step.
3. The first step is the rate-determining step.
4. The reaction is endothermic.
5. If the reaction is heated, the reaction rate will increase.

a. 1, 2, and 5 ***b.** 1, 3, and 5 **c.** 2 and 4
d. 3, 4, and 5 **e.** 3 and 4

3.47. Which of the following statements about chemical reactions are true?

1. Exothermic reactions occur at a rapid rate.
2. The products of exothermic reactions are lower in energy than the reactants.
3. Exothermic reactions give off heat.
4. The products of endothermic reactions are lower in energy than the reactants.

a. 3 **b.** 1, 2, and 3 **c.** 1, 3, and 4
***d.** 2 and 3 **e.** 2

Reaction Mechanisms

3.48. Markovnikov addition of HCl to propene involves:

a. initial attack by the chloride ion **b.** initial attack by the chlorine atom
c. isomerization of 1-chloropropane **d.** formation of a propyl cation
***e.** formation of an isopropyl cation

3.49. What type of carbocation will form from the addition of a H^+ to 2-methylpropene?

a. H_3C^+ **b.** 1° **c.** 2° ***d.** 3° **e.** allyl

3.50. Cyclohexene is treated with cold dilute $KMnO_4$. What is the spatial arrangement of the hydroxyls on the resulting cyclohexane ring?

***a.** *cis* **b.** *trans* **c.** eclipsed
d. both axial **e.** both equatorial

3.51. The first step in the free radical mechanism for the preparation of polyethylene is:

a. formation of a stable carbocation
b. formation of a stable carbanion
***c.** heating an organic peroxide to break the O–O bond
d. decoupling of the free radicals
e. propagation of the free radicals

3.52. Polyethylene is usually produced by

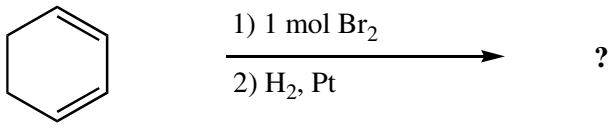
a. an ionic electrophilic addition reaction. **b.** heating ethylene to 1000°C.
c. cationic polymerization. ***d.** a free-radical chain reaction.
e. epoxidation.

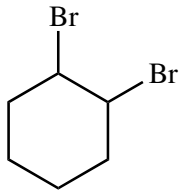
Miscellaneous

3.53. Which of the following reagents can be used to distinguish an alkene from an alkane?

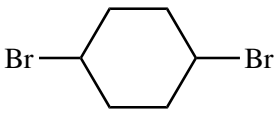
a. Zn, H^+ **b.** H_2O **c.** Cl_2, hν ***d.** Br_2, CCl_4 **e.** O_2, heat

3.54. What is/are the final product(s) in the following multistep synthesis?

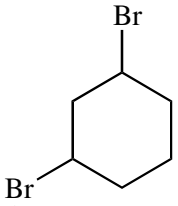




I



II



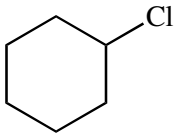
III

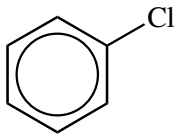
a. I **b.** II **c.** III
***d.** I and II **e.** all are produced

Chapter 4
Aromatic Compounds

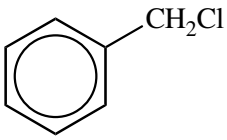
Nomenclature and Structural Formulas of Aromatic Compounds

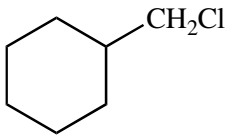
4.1. The structure of chlorobenzene is correctly represented by:

a. 

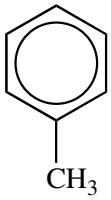
***b.** 

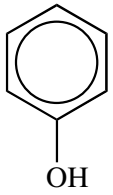
c. 

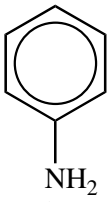
d. 

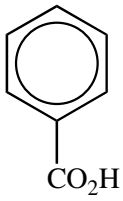
e. 

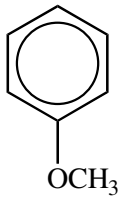
4.2. Which of the following structures accurately represents toluene?

***a.** 

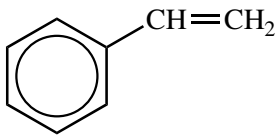
b. 

c. 

d. 

e. 

4.3. The name of the following molecule is:

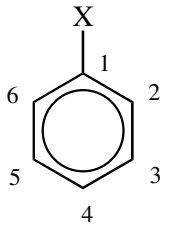


a. toluene **b.** ethylbenzene **c.** cumene ***d.** styrene **e.** anisole

4.4. What dibromobenzene can form *only one* tribromobenzene?

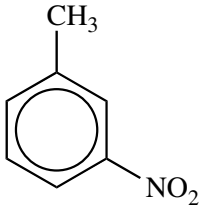
a. *o*-dibromobenzene **b.** *m*-dibromobenzene ***c.** *p*-dibromobenzene
d. cumene **e.** styrene

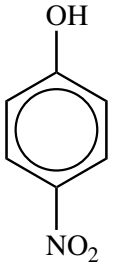
4.5. Using the following monosubstituted benzene, which position would be ortho to X?

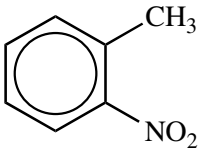


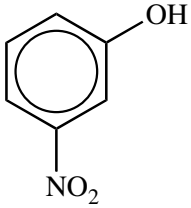
a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** 5

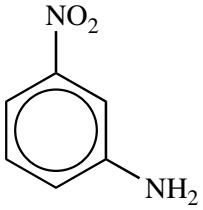
4.6. Which of the following molecules is *m*-nitrophenol?

a. 

b. 

c. 

***d.** 

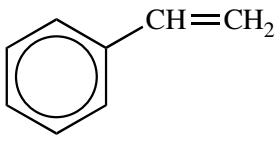
e. 

4.7. What is the name of the following molecule?

$PhCH_2CH_2CH{=}CH_2$

a. styrene ***b.** 4-phenyl-1-butene **c.** 1-phenyl-3-butene
d. 3-benzyl-1-propene **e.** allylbenzene

4.8. Which name(s) of the following molecule is/are *incorrect*?



a. styrene **b.** vinylbenzene ***c.** ethylbenzene
d. phenylethene **e.** a and b

4.9. How many dinitrobenzoic acids are possible?

a. 4 **b.** 5 ***c.** 6 **d.** 7 **e.** 8

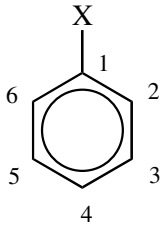
4.10. Which of the following names represents more than one compound?

***a.** dichlorobenzene **b.** 2-bromophenol
c. *o*-nitrobenzaldehyde **d.** 2,4,6-trinitrotoluene
e. cumene

4.11. How many different trisubstituted products are possible from the nitration of *m*-xylene?

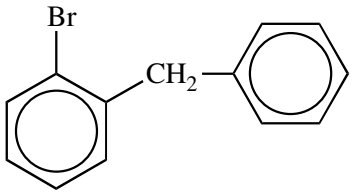
a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

4.12. Which position would be meta to X?



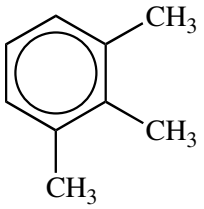
a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 6

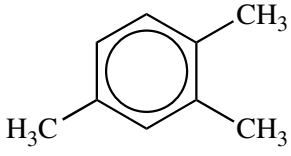
4.13. What is the correct name for the following molecule?

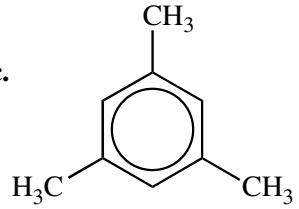


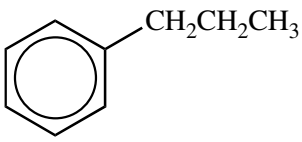
a. *o*-bromobenzyl **b.** biphenyl bromide
c. 2-bromodiphenylpropane **d.** bromobenzylbenzene
***e.** *o*-benzylbromobenzene

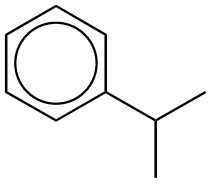
4.14. Which alkylbenzene, C_9H_{12}, when nitrated can yield only one mononitro product?

a. 

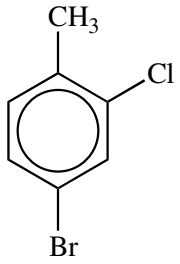
b. 

***c.** 

d. 

e. 

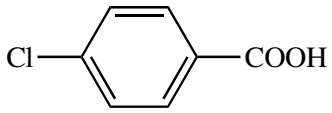
4.15. The correct name for

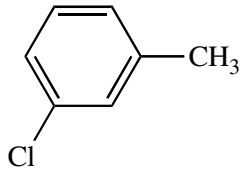


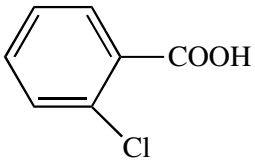
is

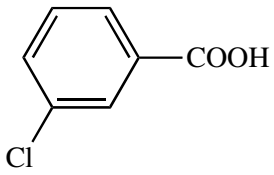
a. 2-chloro-4-bromotoluene.
b. *o*-chloro-*p*-bromotoluene.
c. 1-bromo-3-chloro-4-methylbenzene.
***d.** 4-bromo-2-chlorotoluene.
e. *m*-chlorobromotoluene.

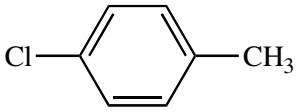
4.16. The structural formula for *m*-chlorobenzoic acid is

a. 

b. 

c. 

***d.** 

e. 

Aromaticity, Resonance, and Properties of Aromatic Compounds

4.17. Which of the following statements about benzene is FALSE?

a. the molecule is planar and each carbon is at a corner of regular hexagon
b. there are two resonance structures of equivalent energy
c. the bond angles are all 120º and the bond lengths are all 1.39Å
***d.** the typical mechanism by which reactions occur is by addition
e. each carbon in the benzene ring is sp^2 hybridized

4.18. Which statement about benzene is TRUE?

a. All six hydrogens in benzene are chemically equivalent.
b. Benzene decolorizes bromine solutions.
c. The molecule is planar, and each carbon is at the corner of a regular hexagon.
***d.** Both a and c are true.
e. Both b and c are true.

Mechanism of Electrophilic Aromatic Substitution

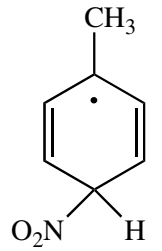
4.19. Which of the following is NOT an electrophile in an electrophilic aromatic substitution reaction?

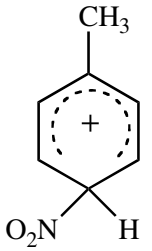
a. NO_2^+ **b.** $Cl^{\delta+}\text{--}^{\delta-}Cl\text{--}FeCl_3$ ***c.** CH_3OH
d. SO_3 **e.** all are

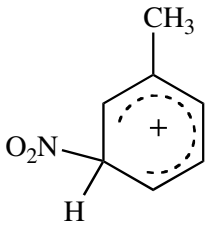
4.20. In the mechanism for the nitration of benzene, what is the function of H_2SO_4?

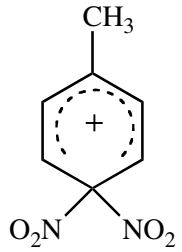
a. to act solely as a solvent ***b.** to donate a proton to HNO_3
c. to accept a proton from HNO_3 **d.** to generate heat for reaction to occur
e. to protonate the benzene ring

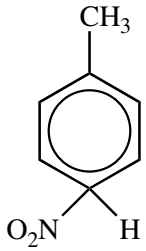
4.21. The predominant intermediate in electrophilic nitration of toluene is

a.


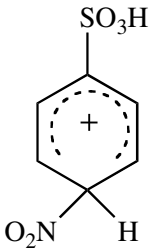
***b.**


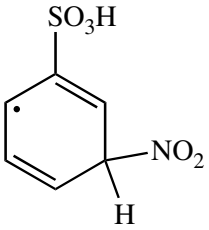
c.


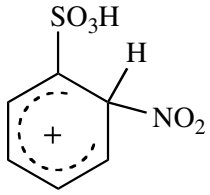
d.


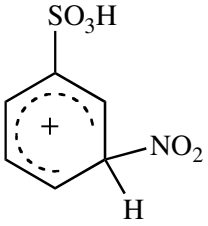
e.


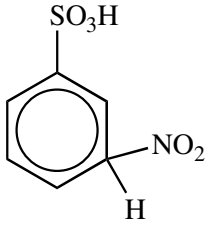
4.22. The predominant intermediate in the nitration of benzenesulfonic acid is

a. 

b. 

c. 

***d.** 

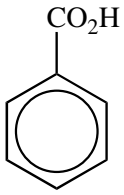
e. 

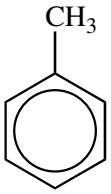
Directing Groups and Ring Activation

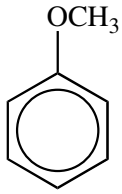
4.23. Which of the following groups is a *meta* director?

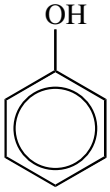
a. –Cl ***b.** –CHO **c.** $-OCH_3$ **d.** –OH **e.** –Ar

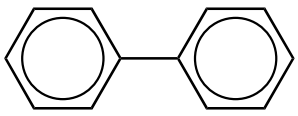
4.24. In electrophilic aromatic substitution reactions, which of the following molecules are considered to be less reactive than benzene?

***a.** 

b. 

c. 

d. 

e. 

4.25. Which of the following groups are *ortho*, *para*-directing?

a. $—CO_2CH_3$ **b.** $—CONH_2$ **c.** $—SO_3H$

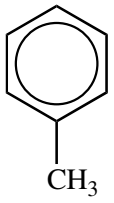
d. $—\overset{+}{N}H(CH_3)_2$ ***e.** $—SCH_3$

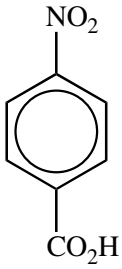
4.26. Among the following groups, which ones are *meta*-directing?

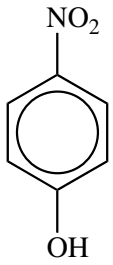
1. –Cl 2. $–NO_2$ 3. $–SO_3H$ 4. $–CH_3$ 5. $–COCH_3$

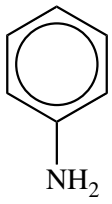
a. 1 and 4 **b.** 1, 2 and 3 ***c.** 2, 3 and 5
d. 2 and 5 **e.** 1 and 2

4.27. Which of the following molecules is the *most* reactive toward electrophilic aromatic substitution?

a. 

b. 

c. 

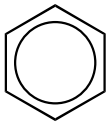
***d.** 

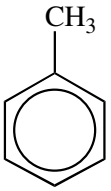
e. 

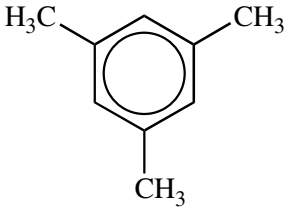
4.28. Which group is both *ortho*, *para*-directing and ring-deactivating?

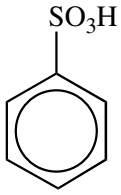
***a.** –Br **b.** –Ar **c.** $–NO_2$ **d.** –CHO **e.** $–OCH_3$

4.29. The relative rates of nitration of

1. 

2. 

3. 

4. 

are

a. 1 > 2 > 3 > 4 **b.** 4 > 2 > 1 > 3 **c.** 2 > 1 > 4 > 3
d. 3 > 4 > 2 > 1 ***e.** 3 > 2 > 1 > 4

4.30. The only group among the following that is *m*-directing is

a. —O—C(=O)—R **b.** —Cl ***c.** —C(=O)—OR

d. —$C(CH_3)_3$ **e.** —$N(CH_3)_2$

4.31. Among the following groups, which ones are *o,p*-directing?

1. —OCH_3 2. —NO_2 3. —Br 4. —CN 5. —CH_2CH_3

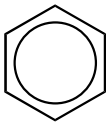
***a.** 1, 3, and 5 **b.** 1 and 5 **c.** 2 and 4 **d.** 2, 3, and 4 **e.** 1 and 3

Reactions of Benzene and Substituted Benzenes

4.32. Which electrophile is used to make acetophenone from benzene?

a. $\overset{+}{C}H_3$ ***b.** $CH_3\overset{+}{C}O$ **c.** SO_3 **d.** NO_2^+ **e.** $CH_3\overset{+}{C}H_2$

4.33. The name of the product of the following reaction is:

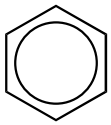

+ HNO_3 $\xrightarrow{H_2SO_4}$ **?**

a. benzenesulfonic acid **b.** aniline **c.** benzoic acid
***d.** nitrobenzene **e.** anisole

4.34. If *p*-nitrophenol is treated with chlorine in the presence of $AlCl_3$, the only trisubstituted product observed is:

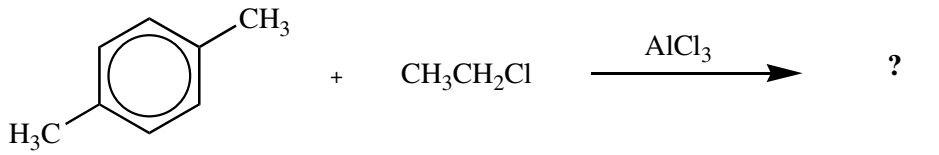
***a.** 2-chloro-4-nitrophenol **b.** 3-chloro-4-nitrophenol
c. 3-chloro-5-nitrophenol **d.** 4-chloro-2-nitrophenol
e. 4-chloro-3-nitrophenol

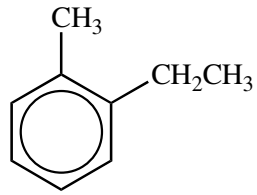
4.35. What is the name of the major product from the following sequence of reactions?

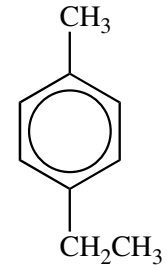

$\xrightarrow[2)\ NaOH,\ 200^oC]{1)\ SO_3,\ H_2SO_4}$ **?**

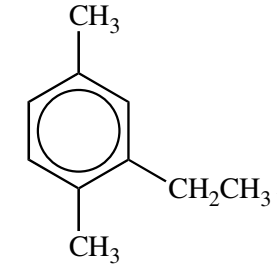
a. aniline **b.** anisole **c.** benzoic acid
***d.** phenol **e.** toluene

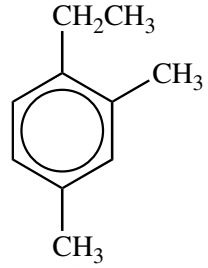
4.36. The expected product from the following reaction is:

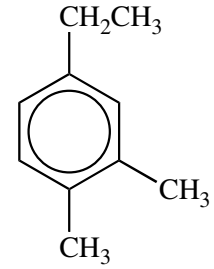


a.


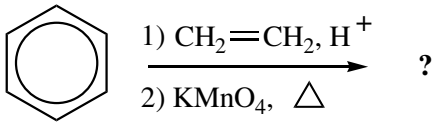
b.


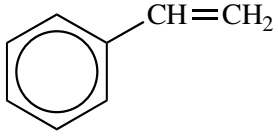
***c.**


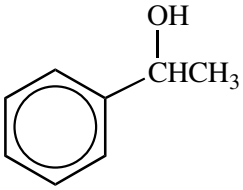
d.


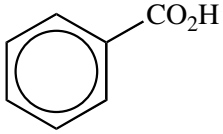
e.


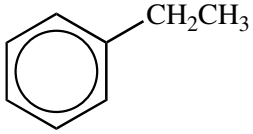
4.37. What is the final product of the following reaction sequence?

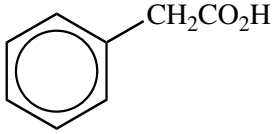


a.


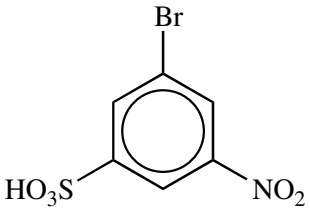
b.


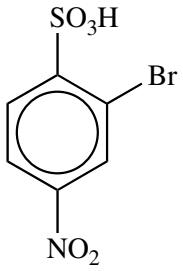
***c.**


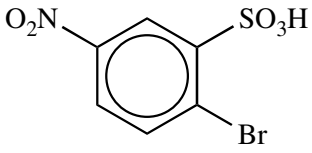
d.


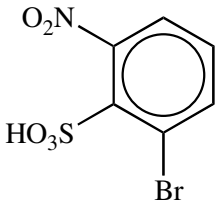
e.


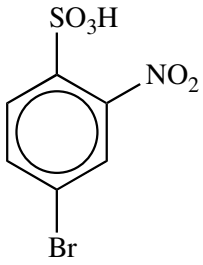
4.38. The predominant product from sequential nitration and bromination of benzenesulfonic acid is

***a.** 

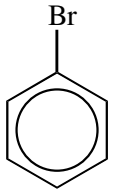
b. 

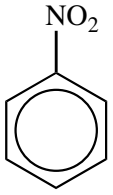
c. 

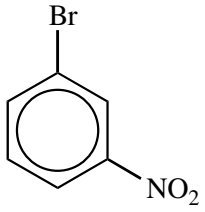
d. 

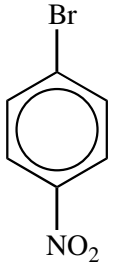
e. 

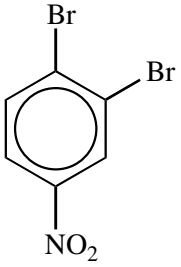
4.39. The predominant product from the sequential bromination and nitration of benzene is:

a. 

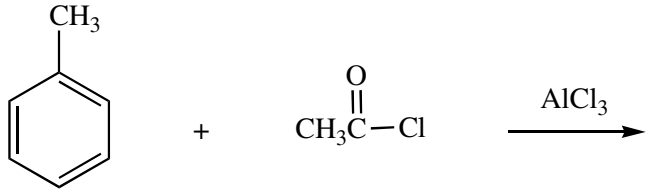
b. 

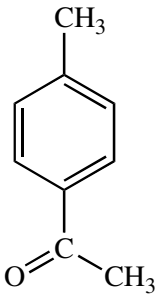
c. 

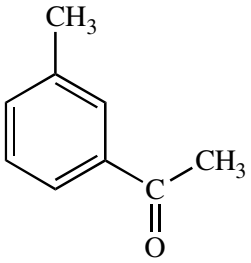
***d.** 

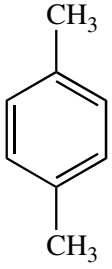
e. 

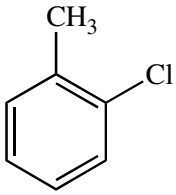
4.40. What is the product of the following reaction?

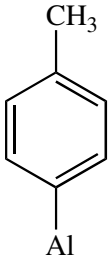


***a.**


b.


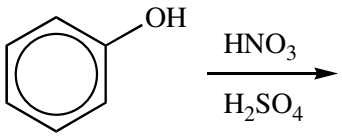
c.


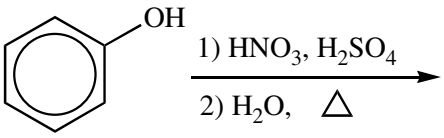
d.


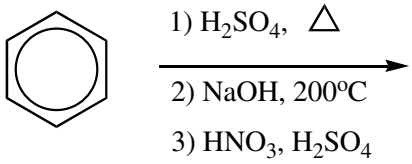
e.


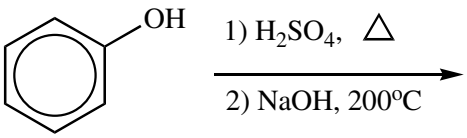
Electrophilic Aromatic Substitution in Synthesis

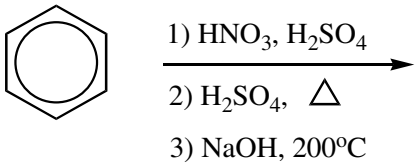
4.41. What is the best sequence of reactions to synthesize *m*-nitrophenol?

a.


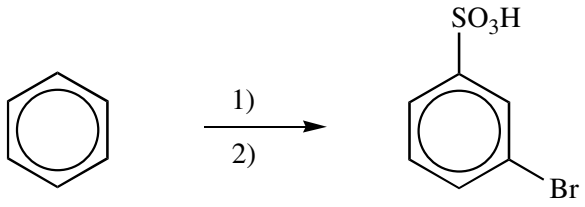
b.


c.


d.


***e.**


4.42. Which is the best reaction sequence to synthesize *m*-bromobenzenesulfonic acid from benzene?

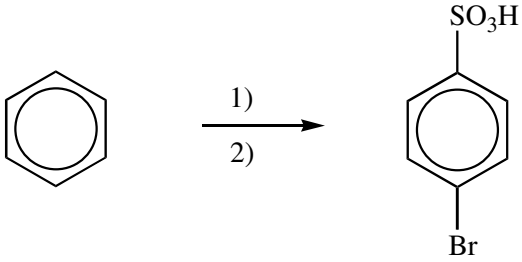


a. 1) Br_2, $AlBr_3$, 2) H_2SO_4, SO_3
***b.** 1) H_2SO_4, SO_3 2) Br_2, $AlBr_3$
c. 1) ethene, HF, 2) Br_2, $AlBr_3$
d. 1) CH_3Cl, $AlCl_3$, 2) Br_2, $AlBr_3$
e. 1) Br_2, $AlBr_3$, 2) CH_3COCl, $AlCl_3$

4.43. Which is the best sequence of reagents to use in synthesizing 2-bromo-4-nitrotoluene from benzene:

a. Br_2, $FeBr_3$; then CH_3Cl, $AlCl_3$; then HNO_3, H_2SO_4
b. CH_3Cl, $AlCl_3$; then Br_2, $FeBr_3$; then HNO_3, H_2SO_4
***c.** CH_3Cl, $AlCl_3$; then HNO_3, H_2SO_4; then Br_2, $FeBr_3$
d. SO_3, H_2SO_4; then HNO_3, H_2SO_4; then Br_2, $FeBr_3$
e. HNO_3, H_2SO_4; then Br_2, $FeBr_3$; then CH_3Cl, $AlCl_3$

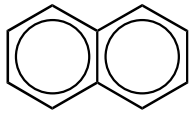
4.44. Which is the best reaction sequence to synthesize *p*-bromobenzenesulfonic acid from benzene?

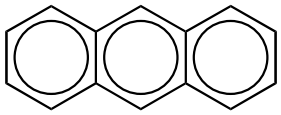


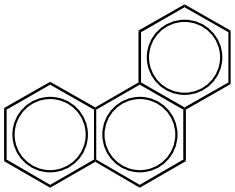
***a.** 1) Br_2, $AlBr_3$, 2) H_2SO_4, SO_3
b. 1) H_2SO_4, SO_3, 2) Br_2, $AlBr_3$
c. 1) CH_3Cl, $AlCl_3$, 2) Br_2, $AlBr_3$
d. 1) Br_2, $AlBr_3$, 2) CH_3COCl, $AlCl_3$
e. 1) HBr, ethane, 2) H_2SO_4, SO_3

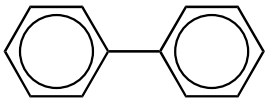
Polycyclic Aromatic Hydrocarbons

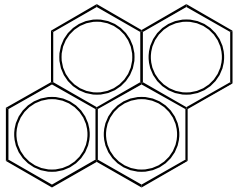
4.45. A common polycyclic aromatic hydrocarbon is named naphthalene. What is the structure of naphthalene?

***a.** 

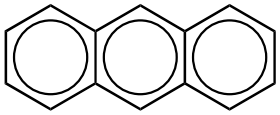
b. 

c. 

d. 

e. 

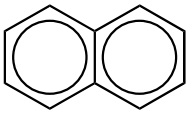
4.46. The number of possible mononitration products of anthracene

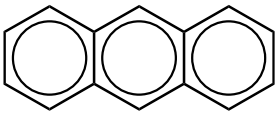


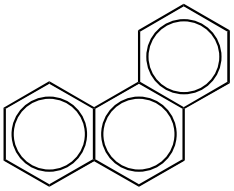
is:

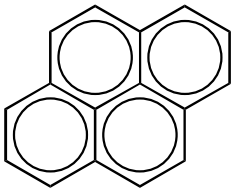
a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

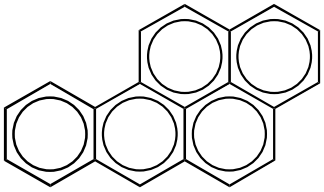
4.47. The polycyclic aromatic hydrocarbon benzo[a]pyrene is a known carcinogen found in soot and tobacco smoke. What is its structure?

a. 

b. 

c. 

d. 

***e.** 

Chapter 5
Stereoisomerism

Definitions

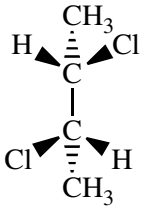
5.1. Which of the following objects is chiral?

a. socks **b.** pencil **c.** cross country skis
d. basketball ***e.** shoes

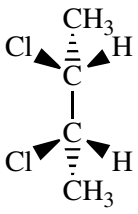
5.2. Chiral molecules that have nonsuperimposable mirror images are called:

***a.** enantiomers **b.** diastereomers **c.** *meso* compounds
d. stereogenic **e.** symmetrical

5.3. Which of the following molecules has a mirror plane of symmetry?



1



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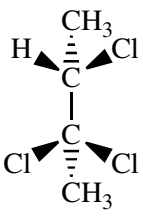
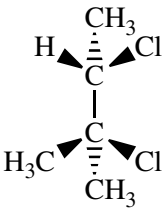


3



4

a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** all of them

5.4. What is the process that separates enantiomers?

a. separation **b.** decoupling **c.** resetting
***d.** resolution **e.** selective binding

5.5. A 50:50 mixture of enantiomers

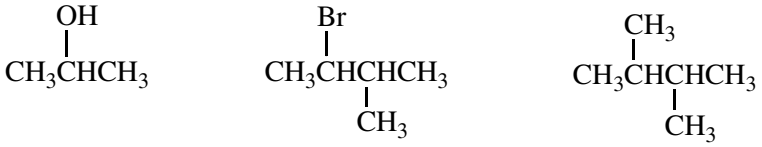
a. is a *meso* form. **b.** is a pair of diastereomers.
***c.** is a racemic mixture. **d.** rotates plane polarized light.
e. is a pair of conformers.

5.6. The terms that best describe the isomeric relationship between staggered and eclipsed ethane are

a. configurational, achiral, diastereomers. **b.** conformational, chiral, enantiomers.
***c.** conformational, achiral, diastereomers. **d.** configurational, chiral, enantiomers.
e. conformational, achiral, enantiomers.

Stereogenic Centers

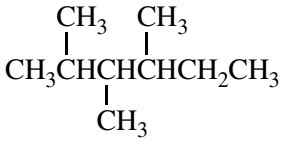
5.7. Which of the molecules below has a stereogenic carbon atom?



1 2 3

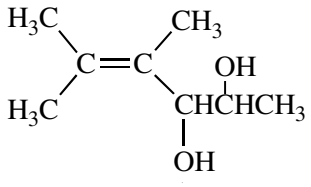
a. 1 ***b.** 2 **c.** 3
d. 2 and 3 **e.** 1, 2, and 3

5.8. How many stereogenic centers are present in the following molecule?



a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** 5

5.9. How many stereogenic centers are present in the following molecule?

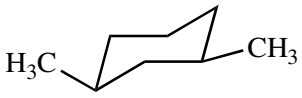


a. 1 ***b.** 2 **c.** 4 **d.** 6 **e.** 8

5.10. How many chiral stereoisomers can be drawn for $CH_3CHClCHBrCH_3$?

a. 1 **b.** 2 **c.** 3 ***d.** 4 **e.** 8

5.11. How many stereogenic carbons are in the following molecule?



a. 0 **b.** 1 ***c.** 2 **d.** 3 **e.** 4

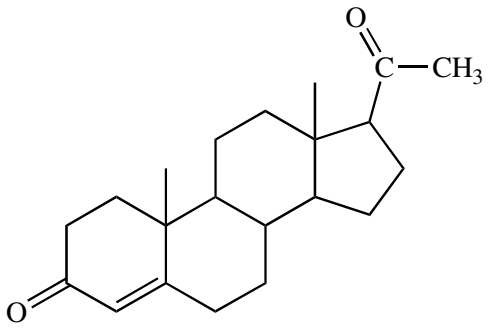
5.12. How many *stereoisomers* can be obtained from the monobromination of butane?

a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** 5

5.13. How many stereoisomers with the formula $CH_3CHICHICH_3$ are possible?

a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

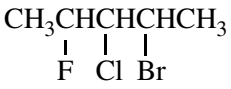
5.14. The number of stereogenic centers in progesterone is



progesterone (no stereochemistry shown)

a. 2 **b.** 3 **c.** 4 **d.** 5 ***e.** 6

5.15. The total number of possible stereoisomers of



is

a. 2 **b.** 4 **c.** 6 ***d.** 8 **e.** 0

5.16. The total number of possible stereoisomers of 2-methyl-1-chlorocyclohexane is

a. 2 ***b.** 4 **c.** 6 **d.** 8 **e.** 0

Optical Activity

5.17. An unknown sample is tested with a polarimeter for optical activity. The results of the test required no movement of the analyzer. What samples would give this result?

a. pure enantiomer **b.** *meso* compound **c.** racemic mixture
***d.** both b and c **e.** none of these

5.18. An unknown sample is tested with a polarimeter for optical activity. The results of the test require movement of the analyzer. What samples would give this result?

***a.** pure enantiomer **b.** *meso* compound **c.** racemic mixture
d. both b and c **e.** none of these

5.19. Which of the following statements about enantiomers is INCORRECT?

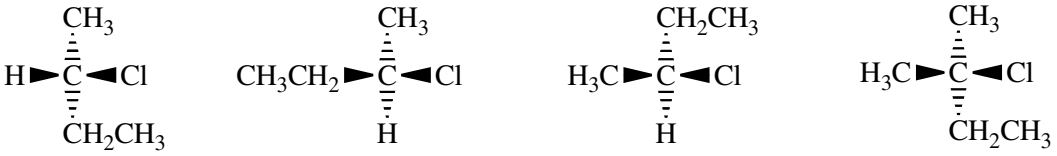
a. they cannot be differentiated by spectra
b. they have the same melting and boiling points
c. the mirror image of the *R* stereoisomer is the *S* stereoisomer
d. the specific rotation of each stereoisomer has the same magnitude
***e.** without exception the *R* stereoisomers will rotate light to the right

5.20. The observed rotation for 100 mL of an aqueous solution containing 1 g of sucrose, placed in a 2-decimeter sample tube, is +1.33° at 25°C. What is the specific rotation of sucrose?

***a.** +66.5° **b.** +266° **c.** +41.5 **d.** +133° **e.** 108°

Relationships Between Stereoisomers

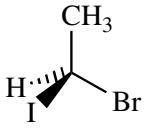
5.21. Which of the following molecules are the same?

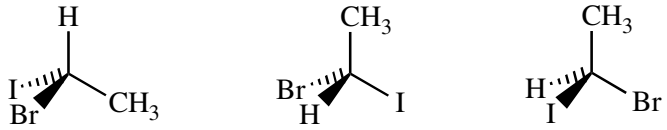


1 2 3 4

a. 1 and 2 **b.** 3 and 4 ***c.** 1 and 3 **d.** 2 and 3 **e.** 2 and 4

5.22. Which of the three molecules below is the enantiomer of the following molecule?

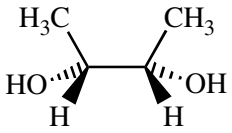


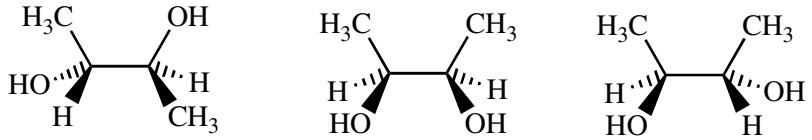


I II III

***a.** I **b.** II **c.** III
d. there are no enantiomers **e.** both II and III

5.23. Which of the three molecules below is a diastereomer of the following molecule?





I II III

a. I **b.** II ***c.** III
d. there are no diastereomers **e.** both I and II

5.24. Which of the following are achiral *conformers*?

***a.** staggered and eclipsed forms of ethane
b. *cis* and *trans*-2-butene
c. *meso* and (2*R*,3*R*)-2,3-dibromobutane
d. (*R*) and (*S*)-lactic acid
e. *E*- and *Z*-2-pentene

5.25. Which of the following would constitute a pair of enantiomers?

a. staggered and eclipsed forms of ethane
b. *cis* and *trans*-2-butene
c. *meso*- and (2*R*,3*R*)-2,3-dibromobutane
***d.** (2*R*,3*R*) and (2*S*,3*S*)-tartaric acid
e. none of these

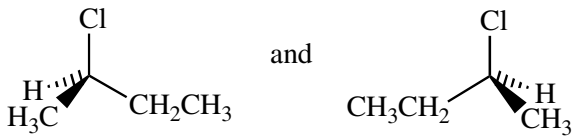
5.26. The terms that best describe the relationship between (2*R*,3*R*)-2,3-butanediol and (2*S*,3*S*)-2,3-butanediol are

a. configurational, achiral, diastereomers.
b. conformational, chiral, enantiomers.
c. conformational, achiral, diastereomers
***d.** configurational, chiral, enantiomers.
e. configurational, achiral, enantiomers.

5.27. The terms that best describe the relationship between (2*R*,3*S*)-2-bromo-3-chlorobutane and (2*R*,3*R*)-2-bromo-3-chlorobutane are

a. configurational, achiral, diastereomers.
b. conformational, chiral, diastereomers.
c. configurational, achiral, enantiomers.
d. conformational, chiral, enantiomers.
***e.** configurational, chiral, diastereomers.

5.28. Which of the following statements about the pair of molecules shown below is *not* true?



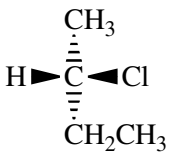
a. They have the same boiling point.
b. One rotates plane polarized light in the opposite direction from the other.
c. They have the same density.
***d.** One rotates plane polarized light a different number of degrees than the other.
e. They are mirror images of each other.

The *R-S* and *E-Z* Conventions

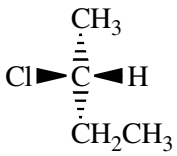
5.29. According to the *R-S* convention, which priority is correct for the following sets of groups?

a. $NH_2 > Cl > CH_3 > H$
***b.** $Cl > NH_2 > CH_3 > H$
c. $Cl > CH_3 > NH_2 > H$
d. $H > Cl > CH_3 > NH_2$
e. $CH_3 > NH_2 > Cl > H$

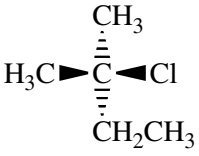
5.30. (*R*)-2-chlorobutane is correctly represented by which of the following:



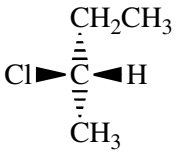
I



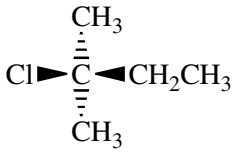
II



III



IV



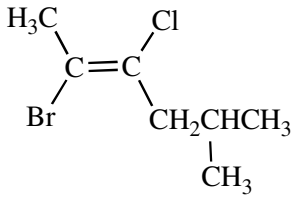
V

a. I ***b.** II **c.** III **d.** IV **e.** V

5.31. Which of the following groups has the highest priority for assigning *R*-*S* absolute configuration?

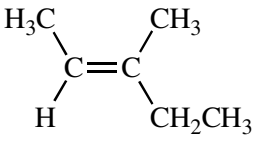
a. CH_2=CH– **b.** $(CH_3)_2$CH– ***c.** $(CH_3)_3$C– **d.** CH_3CH_2– **e.** CH_3–

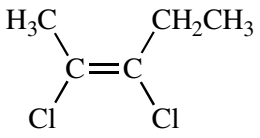
5.32. The correct IUPAC name for the following molecule is:

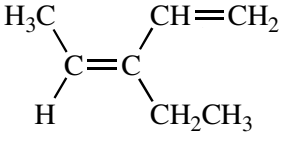


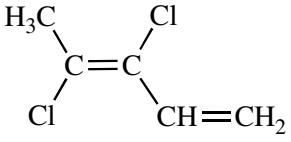
***a.** (*E*)-2-bromo-3-chloro-5-methyl-2-hexene
b. (*E*)-2-bromo-3-chloro-5-methyl-3-hexene
c. (*Z*)-2-bromo-3-chloro-5-methyl-3-hexene
d. (*Z*)-2-bromo-3-chloro-5-methyl-2-hexene
e. (*Z*)-5-bromo-4-chloro-2-methyl-4-hexene

5.33. Which of the following structures is (*Z*)-2,3-dichloro-2-pentene?


1


2


3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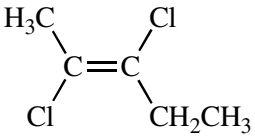
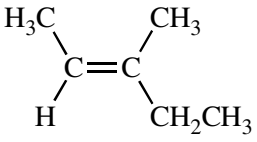
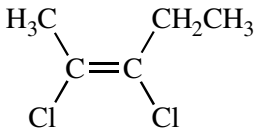
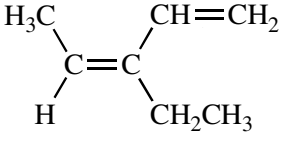

5

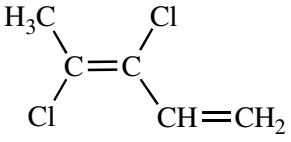
a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** 5

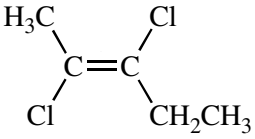
5.34. Of the following structures, how many are classified "*E*"?


1


2

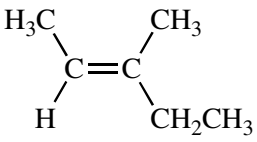

3

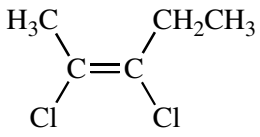

4

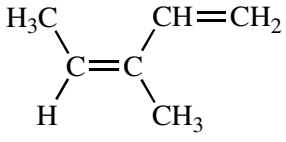

5

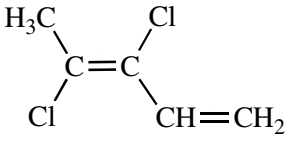
a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

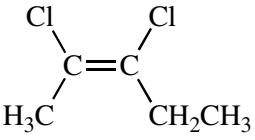
5.35. Of the following structures, how many are classified "*Z*"?





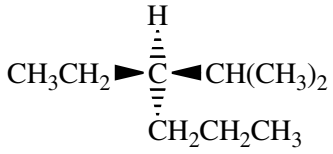


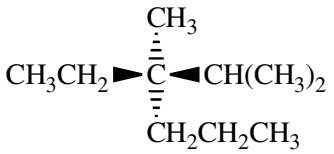


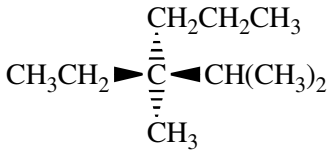


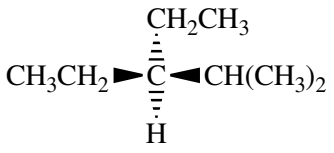
a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

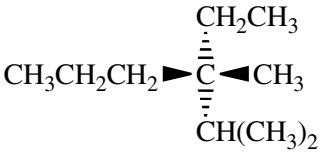
5.36. Which of the following structures depicts (*R*)-3-ethyl-2,3-dimethylhexane?

a. 

***b.** 

c. 

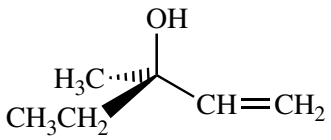
d. 

e. 

5.37. The priority order for *R/S* nomenclature is

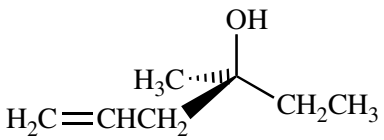
a. —$CH{=}CH_2$ > —OH > —CH_3 > —CH_2CH_3
b. —OH > —CH_2CH_3 > —$CH{=}CH_2$ > —CH_3
***c.** —OH > —$CH{=}CH_2$ > —CH_2CH_3 > —CH_3
d. —CH_3 > —CH_2CH_3 > —$CH{=}CH_2$ > —OH
e. —CH_2CH_3 > —CH_3 > —$CH{=}CH_2$ > —OH

5.38. Which name describes the following structure?



***a.** (*R*)-3-methyl-1-penten-3-ol
b. (*S*)-3-methyl-1-penten-3-ol
c. (*R*)-3-ethyl-1-buten-3-ol
d. (*R*)-3-methyl-1-pentyn-3-ol
e. (*S*)-3-ethyl-1-buten-3-ol

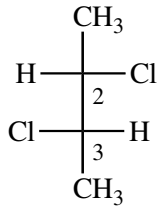
5.39. Which name describes the following structure?



a. (*R*)-4-methyl-1-hexen-4-ol
b. (*S*)-4-ethyl-1-penten-4-ol
c. (*R*)-4-ethyl-1-penten-3-ol
***d.** (*S*)-4-methyl-1-hexen-4-ol
e. (*S*)-4-methyl-1-hexyn-4-ol

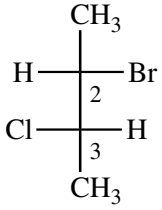
Fischer and Newman Projections

5.40. What is correct name for the following structure?



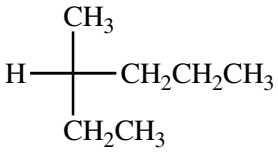
a. (*R*,*S*)-2,3-dichlorobutane
b. (2*R*,3*S*)-2,3-dichlorobutane
***c.** (2*S*,3*S*)-2,3-dichlorobutane
d. (2*R*,3*R*)-2,3-dichlorobutane
e. none of these

5.41. What is the absolute configuration around C-2 and C-3?



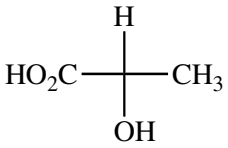
a. *R, R* ***b.** *S, S* **c.** *R, S* **d.** *S, R* **e.** *E, Z*

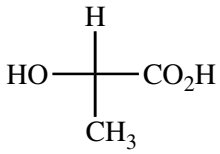
5.42. The absolute configuration around the stereogenic center of the molecule below is:

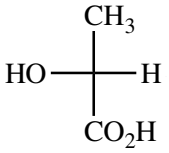


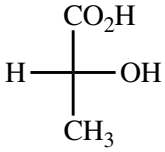
a. *R* ***b.** *S* **c.** *E* **d.** *Z* **e.** *trans*

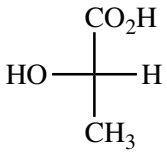
5.43. The Fischer projection formula for (*S*)-lactic acid (2-hydroxypropanoic acid) is

a. 

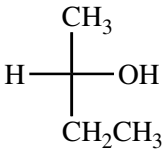
b. 

c. 

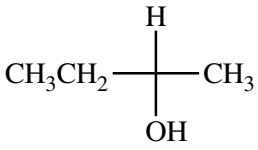
d. 

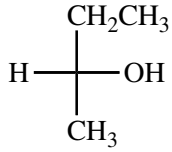
***e.** 

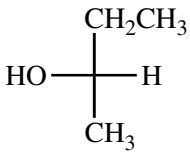
5.44. The Fischer projection that represents the same molecule as

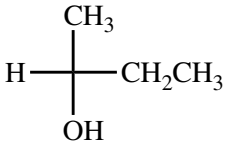


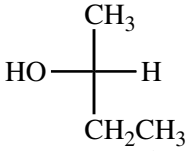
is:

a. 

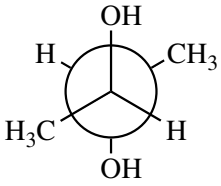
b. 

***c.** 

d. 

e. 

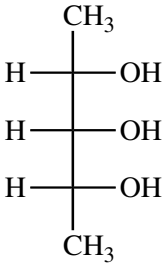
5.45.

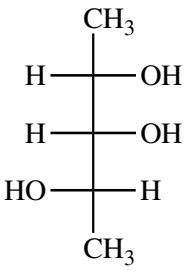


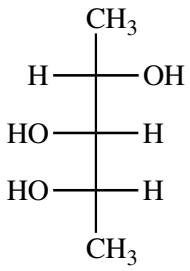
represents

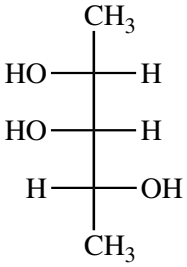
a. (2*R*,3*R*)-2,3-butanediol.
b. (2*S*,3*S*)-2,3-butanediol.
c. the most stable conformer of (2*R*,3*R*)-2,3-butanediol.
d. the least stable conformer of (2*R*,3*R*)-2,3-butanediol.
***e.** *meso*-2,3-butanediol.

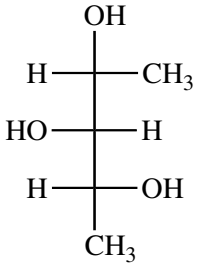
5.46. Which one of the following structures represents a meso compound?

***a.** 

b. 

c. 

d. 

e. 

Stereochemistry and Chemical Reactions

5.47. When (*R*)-3-bromo-2-methyl-1-butene is reacted with HBr, two stereoisomers are formed. What is the relationship of these stereoisomers?

a. enantiomers **b.** *meso* compounds ***c.** diastereomers
d. *E* **e.** *Z*

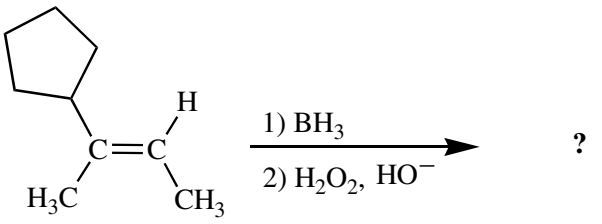
5.48. Treating 1-butene with HCl produces a product with one stereogenic carbon. What is the name of the product?

a. 2-chloro-1-butene **b.** 1-chlorobutane **c.** (*R*)-2-chlorobutane
d. (*S*)-2-chlorobutane ***e.** both c and d in equal amounts

5.49. When (*S*)-3-bromo-1-butene is treated with HBr, two stereoisomeric products form. What is the relationship of these two products?

a. enantiomers ***b.** diastereomers **c.** *meso* compounds
d. racemic mixture **e.** cis/trans

5.50. How many stereogenic carbons are produced from the following sequence of reactions?



a. 1 ***b.** 2 **c.** 3 **d.** 4 **e.** 5

5.51. Enantiomers may differ in the following property:

***a.** the rate at which they react with a chiral reagent
b. boiling point
c. melting point
d. number of degrees they rotate plane polarized light
e. solubility in water

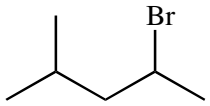
5.52. The product of addition of bromine to (*R*)-3-buten-2-ol will be

a. a 50:50 mixture of enantiomers.
b. a mixture of enantiomers formed in unequal amounts.
c. a 50:50 mixture of diastereomers.
***d.** a mixture of diastereomers formed in unequal amounts.
e. optically inactive.

Chapter 6
Organic Halogen Compounds; Substitution and Elimination Reactions

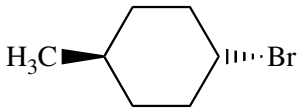
Nomenclature of Halides

6.1. What is the IUPAC name of the following alkyl halide?



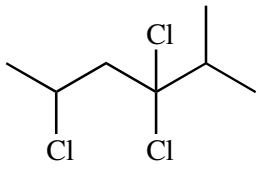
*__a.__ 2-bromo-4-methylpentane
__b.__ 4-methyl-2-bromopentane
__c.__ 2-methyl-4-bromopentane
__d.__ 2-bromo-2-methylpentane
__e.__ 2-bromo-1-isopropylpropane

6.2. What is the IUPAC name of the following alkyl halide?

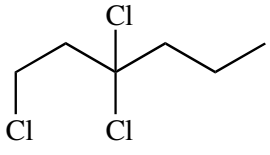


__a.__ *trans-p*-bromotoluene
__b.__ *trans*-4-methylcyclohexyl bromide
*__c.__ *trans*-4-methyl-1-bromocyclohexane
__d.__ *trans*-1-bromo-4-methylcyclohexane
__e.__ *trans-p*-bromomethylcyclohexane

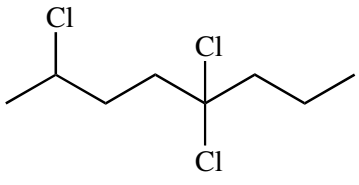
6.3. Which of the following structures represents 2,4,4-trichloroheptane?



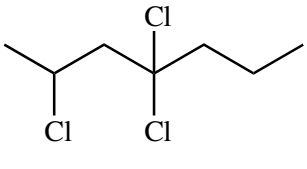
I



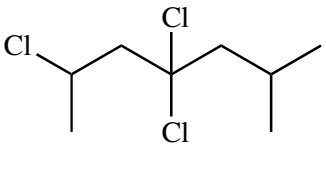
II



III



IV



V

__a.__ I __b.__ II __c.__ III *__d.__ IV __e.__ V

Nucleophiles/Bases/Leaving Groups

6.4. Which of the following is the best nucleophile?

a. CH_3OH **b.** CH_3O^- ***c.** CH_3S^-
d. CH_3SH **e.** all are the same

6.5. Which of the following is the strongest base?

a. H_2O **b.** ^-OH **c.** NH_3 ***d.** $^-NH_2$ **e.** F^-

6.6. Which of the following is the best leaving group?

a. HO^- **b.** Cl^- ***c.** I^- **d.** Br^- **e.** H_2N^-

6.7. Which of the following is the *best* nucleophile?

a. H_2O **b.** CH_4 ***c.** NH_3 **d.** HF

6.8. Which of the following is an *incorrect* representation of relative nucleophile strength?

a. $^-NH_2 > F^-$ ***b.** $HO^- > HS^-$ **c.** $CH_3^- > HO^-$
d. $CH_3O^- > CH_3OH$ **e.** $I^- > Br^-$

6.9. The reactivity order of

1. $CH_3CH_2S^-$
2. $CH_3CH_2O^-$
3. CH_3CH_2OH

as nucleophiles is

***a.** 1 > 2 > 3 **b.** 2 > 3 > 1 **c.** 2 > 1 > 3
d. 3 > 2 > 1 **e.** 1 > 3 > 2

Reaction Mechanisms

6.10. What is the mechanism of the following reaction?

$$CH_3Br + {}^-OH \longrightarrow CH_3OH + Br^-$$

a. S_N1 ***b.** S_N2 **c.** E1
d. E2 **e.** both a and b

6.11. Which statement is true for S_N2 reactions?

a. The rate of the reaction is dependent on the stability of a carbocation.
b. The rate of reaction is dependent on just the substrate.
c. The fastest reaction will occur with a tertiary halide.
***d.** Displacement occurs with inversion of configuration.
e. The mechanism is a two step process.

6.12. Which bromide reacts fastest in S_N2 reactions?

***a.** CH_3Br **b.** $(CH_3)_2CHBr$ **c.** $(CH_3)_3CBr$
d. $(CH_3)_3CCH_2Br$ **e.** CH_3CH_2Br

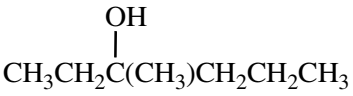
6.13. Which of the following is a polar aprotic solvent?

a. H_2O **b.** $(CH_3)_2NCHO$ **c.** CH_3OH
d. $(CH_3)_2S{=}O$ ***e.** both b and d

6.14. Which statement(s) is/are true of an E1 elimination?

a. it is a two-step process and has the same first step as a S_N1 mechanism
b. it involves the formation of the carbocation from elimination of a good leaving group
c. a common competing reaction is rearrangement of a less stable carbocation to a more stable carbocation
d. the loss of a proton by the carbocation is a fast step
***e.** all of the above

6.15. When (*R*)-3-bromo-3-methylhexane is treated with H_2O, racemic



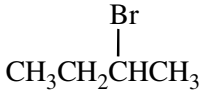
is produced. By what mechanism does this reaction occur?

***a.** S_N1 **b.** S_N2 **c.** E1
d. E2 **e.** cannot be explained by one mechanism

6.16. The slowest step of an S_N1 reaction involves:

a. attack of the nucleophile on the substrate to form a pentavalent carbon.
***b.** breaking the bond between the carbon and the leaving group to give a carbocation.
c. combination of a nucleophile with the carbocation to give the product.
d. loss of a proton from the nucleophile to give the product.
e. none of the above.

6.17. Which of the following bromides will react faster with CH_3OH in an S_N1 reaction?

a.  **b.** $CH_3CH_2CH_2Br$

c. $CH_2{=}CHCH_2CH_2Br$ ***d.** $(CH_3)_2CBrCH_2CH_3$

e. CH_3Br

6.18. The S_N2 mechanism for nucleophilic substitution reactions

a. involves two steps and occurs with inversion of configuration.
***b.** involves one step and occurs with inversion of configuration.
c. involves two steps and occurs with racemization.
d. involves one step and occurs with retention of configuration.
e. involves one step and occurs with racemization.

6.19. The S_N1 mechanism for nucleophilic substitution reactions

a. involves one step and occurs fastest with primary halides.
b. involves one step and occurs fastest with tertiary halides.
***c.** involves two steps and occurs fastest with tertiary halides.
d. involves two steps and occurs fastest with primary halides.
e. involves one step and occurs fastest with aromatic halides.

6.20. The expected S_N2 reactivity order of

1. $H_2C{=}CHCHBr$ (Br) 2. $CH_3CH{=}CHCH_2Br$ 3. $CH_2{=}CHC(CH_3)_2Br$

is:

***a.** 2 > 1 > 3 **b.** 2 > 3 > 1 **c.** 1 > 2 > 3
d. 1 > 3 > 2 **e.** 3 > 1 > 2

6.21. $CH_3CH_2C(CH_3)_2Br + (CH_3)_3CO^-K^+$ are most likely to react by

a. a free-radical chain mechanism. **b.** the S_N1 mechanism.
c. the S_N2 mechanism. **d.** the E1 mechanism.
***e.** the E2 mechanism.

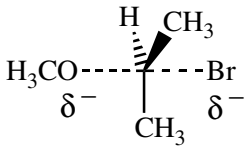
6.22.

$$CH_3CH(Br)CH_3 + Na^+ {}^-SH$$

are most likely to react by

a. a free-radical chain mechanism. **b.** the S_N1 mechanism.
***c.** the S_N2 mechanism. **d.** the E1 mechanism.
e. the E2 mechanism.

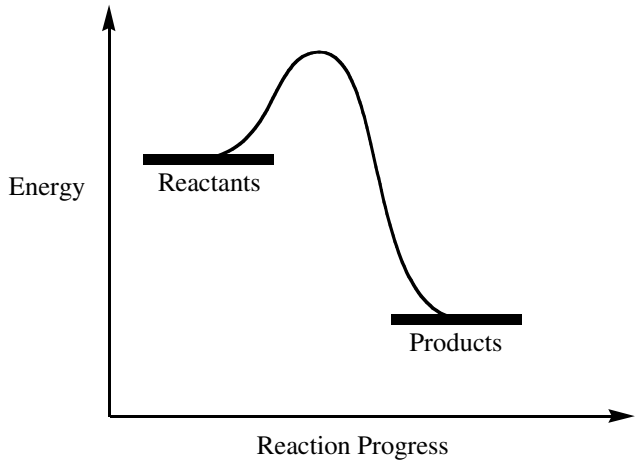
6.23. The structure



represents the transition state for the reaction of

a. methanol with 2-bromopropene.
***b.** methoxide with 2-bromopropane.
c. sodium bromide with isopropyl methyl ether.
d. methanol with 2-bromopropane.
e. methoxide with 1-bromopropane.

6.24. The energy-reaction diagram

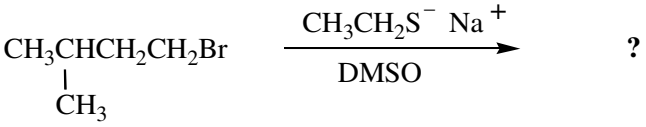


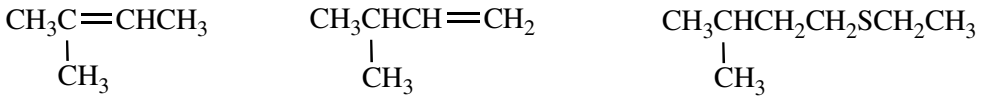
is for

a. an S_N2 reaction only.
b. an S_N1 reaction only.
c. an E2 reaction only.
d. an E1 reaction only.
e. an S_N1 or E1 reaction.
***f.** an S_N2 or E2 reaction

Reactions

6.25. The *major* product of the following reaction is:





I II III

a. I
b. II
***c.** III
d. I and II
e. there is no major product

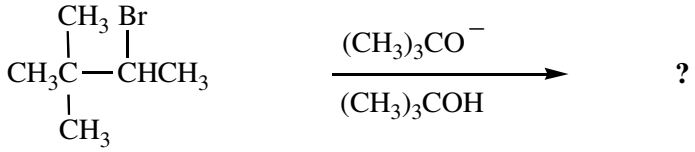
6.26. When 1-chlorobutane is reacted with the bulky base, potassium *t*-butoxide, in *t*-butyl alcohol, the major elimination product is:

***a.** 1-butene
b. *cis*-2-butene
c. *trans*-2-butene
d. butyl *t*-butyl ether
e. butyl alcohol

6.27. How many different *E2 products* can form from the dehydrohalogenation of 2-bromopentane?

a. 1 **b.** 2 ***c.** 3 **d.** 4 **e.** 5

6.28. What is the *major* product of the following reaction?

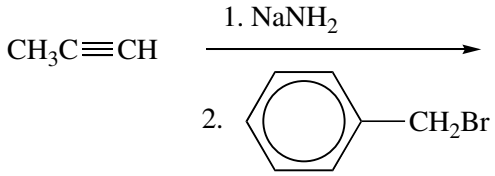


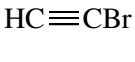
a. $(CH_3)_2C{=}C(CH_3)_2$ ***b.** $(CH_3)_3CCH{=}CH_2$

c. $(CH_3)_2C{=}CHCH_3$ **d.** $(CH_3)_2C{=}CHCH_2CH_3$

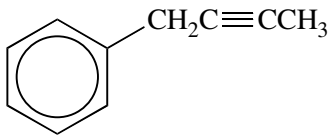
e. none of these

6.29. What is the final product of the following sequence of reactions?

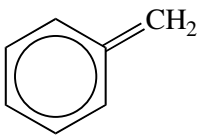




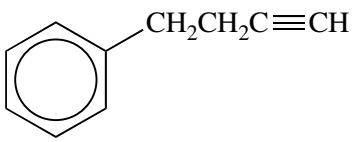
I



II



III



IV

a. I ***b.** II **c.** III
d. IV **e.** III and IV

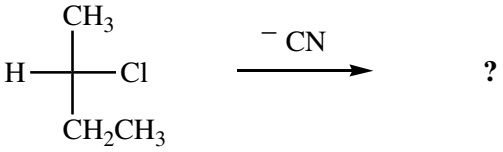
6.30. What alkyne is produced when sodium acetylide reacts with CH_3CH_2I?

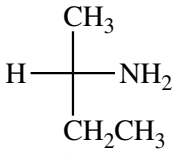
a. 2-butyne ***b.** 1-butyne **c.** 2-butene **d.** 1-butene **e.** propyne

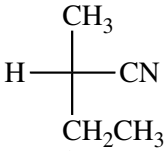
6.31. 1-Butanethiol, $CH_3CH_2CH_2CH_2SH$, is produced by the reaction of 1-bromobutane with:

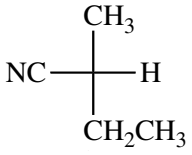
a. NH_3 **b.** CH_3OH **c.** CH_3S^- ***d.** ^-SH **e.** CH_3O^-

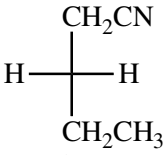
6.32. Which Fischer projection represents the product of the following reaction?

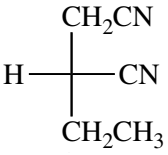


a. 

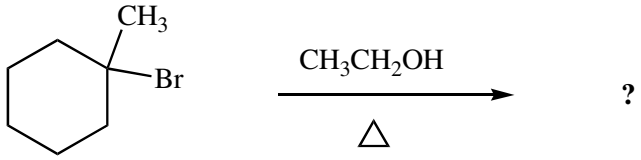
b. 

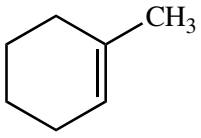
***c.** 

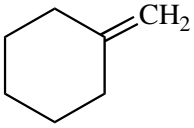
d. 

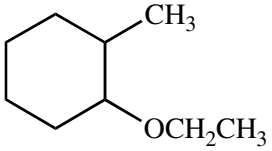
e. 

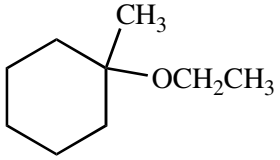
6.33. What is the *major* product of the following reaction?

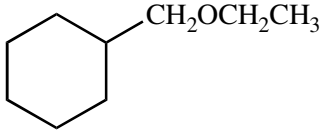


a. 

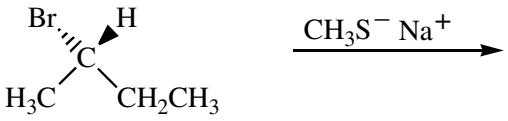
b. 

c. 

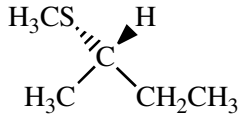
***d.** 

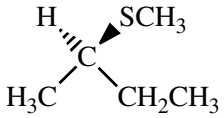
e. 

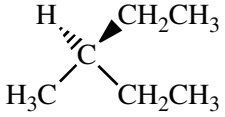
6.34. The major product of the reaction

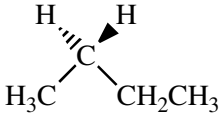


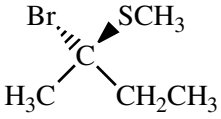
is

a. 

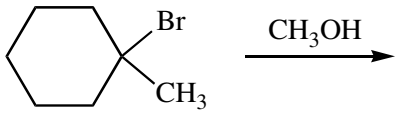
***b.** 

c. 

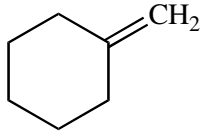
d. 

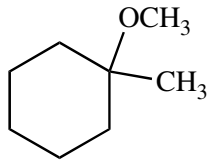
e. 

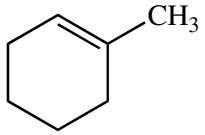
6.35. The products of the following reactions are:

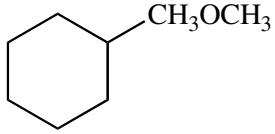


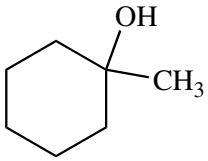
is

I 

II 

III 

IV 

V 

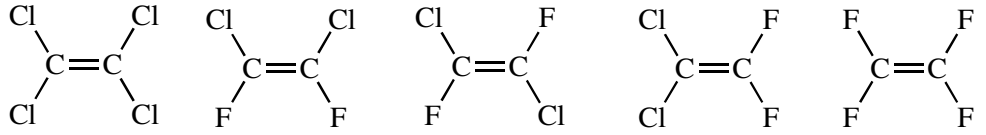
a. I, III ***b.** I, II, III **c.** III, V **d.** II, IV, V **e.** II, III

Miscellaneous

6.36. The monomer used to prepare Teflon is

a. $CH_2=CH_2$ **b.** $CH_2=CHCl$ **c.** $CH_3CH=CH_2$
***d.** $CF_2=CF_2$ **e.** CH_2Cl_2

6.37. Which of the following halocarbons is the raw material for the synthesis of Teflon?



I II III IV V

a. I **b.** II **c.** III **d.** IV ***e.** V

6.38. Polyhalogenated aliphatic compounds have not been used as:

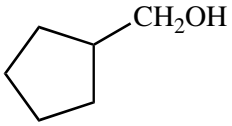
***a**. toothpaste additives **b.** fire retardants **c.** degreasing agents
d. insecticides **e.** refrigerants

Chapter 7
Alcohols, Phenols, and Thiols

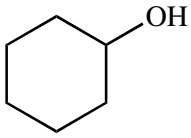
Nomenclature of Alcohols

7.1. Which of the following is a secondary (2°) alcohol?

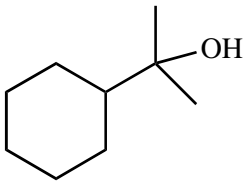
I



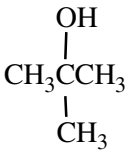
II



III



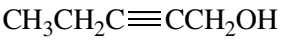
IV

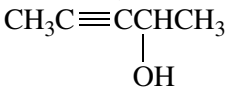


V

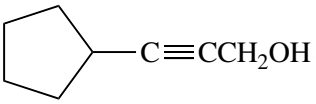
a. I **b.** II ***c.** III **d.** IV **e.** V

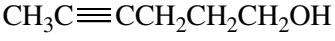
7.2. Which of the following is 3-pentyn-1-ol?

a. 

b. 

***c.**

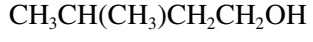
d. 

e. 

7.3. What is the IUPAC name for isobutyl alcohol?

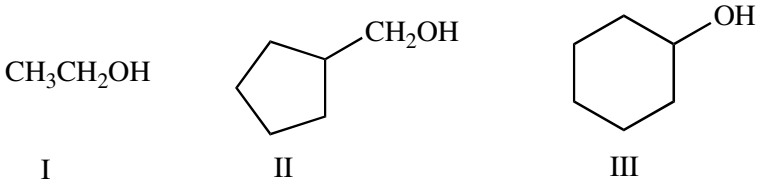
a. 1-butanol **b.** 2-butanol
c. 2-methyl-2-butanol ***d.** 2-methyl-1-propanol
e. 2,2-dimethylpropanol

7.4. What would be the IUPAC name for the following alcohol?

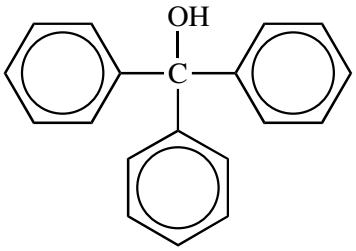


a. 2-methyl-4-butanol **b.** 2-methyl-4-hydroxybutanol
c. 3-methyl-2-butanol **d.** 1-hydroxy-3-methylbutanol
***e.** 3-methyl-1-butanol

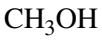
7.5. Which of the following molecules is classified as a tertiary (3°) alcohol?



I II III



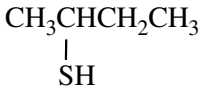
IV



V

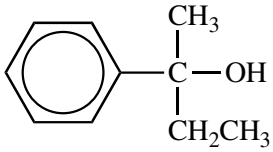
a. I **b.** II **c.** III ***d.** IV **e.** V

7.6. What is the correct name for the following molecule?



a. 2-butanol **b.** 3-thiobutanol ***c.** 2-butanethiol
d. 2-thiobutanol **e.** 3-butanethiol

7.7. What is the name of the following alcohol?

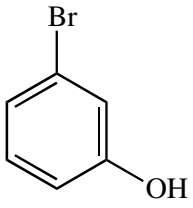


a. 1-ethyl-2-methylbenzyl alcohol **b.** methylphenylpropanol
c. 2-methyl-2-phenyl-1-propanol ***d.** 2-phenyl-2-butanol
e. cumyl alcohol

7.8. What is a correct name for $(CH_3)_2CHO^-\ K^+$?

a. potassium alkoxide **b.** potassium ethoxide
c. potassium propoxide **d.** potassium dimethylethoxide
***e.** potassium isopropoxide

7.9. The correct name for



is

a. 3-hydroxybromobenzene.
b. 3-bromobenzyl alcohol.
c. 3-bromobenzol.
***d.** *m*-bromophenol.
e. *m*-bromobenzol.

7.10. The formula for 2-pentanethiol is:

a. $CH_3CHCH_2CH_2CH_2SH$ (OH)

b. $CH_3CHCHCH_2CH_3$ (HS, OH)

c. $CH_3SCH_2CH_2CH_3$

***d.** $CH_3CHCH_2CH_2CH_3$ (SH)

e. $CH_3SCH_2CH_2CH_2CH_3$

Properties of Alcohols

7.11. Which of the following molecules would be the best hydrogen bond donor?

a. $CH_3CH_2OCH_3$ **b.** CH_3CN ***c.** CH_3OH
d. CH_3SH **e.** $CH_3CH_2NH_2$

7.12. Which of the following molecules would have the highest boiling point?

***a.** CH_3CH_2OH **b.** CH_3OCH_3 **c.** CH_3CH_2Cl **d.** $CH_3CH_2CH_3$ **e.** CH_3CH_2I

7.13. The expected order of boiling points of

1. $CH_3CH_2OCH_3$ 2. $CH_3CH_2CH_2OH$ 3. CH_3CHCH_3 (OH)

is:

a. 3 > 2 > 1 **b.** 1 > 2 > 3 **c.** 1 > 3 > 2 ***d.** 2 > 3 > 1 **e.** 2 > 1 > 3

Acid-Base Chemistry

7.14. A Lewis base is a:

a. proton donor
***b.** electron pair donor
c. electron pair acceptor
d. proton acceptor

7.15. The conjugate base of sulfuric acid, H_2SO_4, is:

a. $H_3SO_4^+$ **b.** SO_3 ***c.** HSO_4^- **d.** H_2SO_3 **e.** HSO_3^-

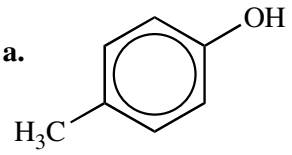
7.16. If the pK_a of isopropyl alcohol is 17, what is the K_a of isopropyl alcohol?

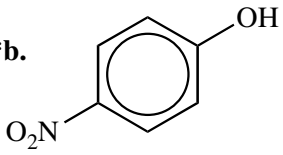
a. 17×10^{-17} ***b.** 10^{-17} **c.** 10^{-3}
d. 10^{17} **e.** 10^{3} **f.** 17×10^{17}

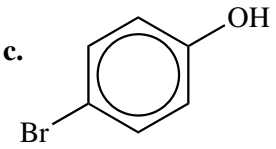
7.17. Which of the following molecules would be the strongest Brønsted-Lowry acid?

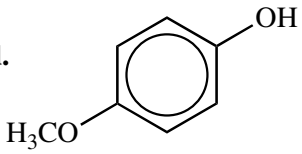
a. H_2O **b.** H_2S **c.** HF ***d.** HCl **e.** CH_4

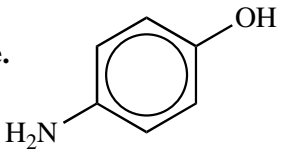
7.18. Which of the following phenols is the strongest acid?

a. 

***b.** 

c. 

d. 

e. 

7.19. Which of the following is the strongest base?

a. CH_3CH_2OH **b.** $CH_3CH_2O^-$ **c.** $CF_3CH_2O^-$

d. $CH_3CH_2S^-$ ***e.** $CH_3CH_2\bar{N}H$

7.20. Electron-withdrawing substituents

a. increase acidity by increasing the stability of acids.
b. decrease acidity by increasing the stability of a conjugate base.
***c.** increase acidity by increasing the stability of a conjugate base.
d. decrease acidity by increasing the stability of acids.
e. can only have a slight effect on acidity.

7.21. Phenols are stronger than alcohols as acids because of

***a.** resonance stabilization of phenoxide ions.
b. resonance stabilization of phenols.
c. resonance stabilization of alkoxide ions.
d. resonance stabilization of alcohols.
e. hydrogen bonding in phenols.

7.22. The pK_a of an acid whose $K_a = 10^{-10}$ is

a. 10^{10} ***b.** 10 **c.** –10 **d.** 1 **e.** –1

Reaction Mechanisms

7.23. Which of the following alcohols would react most rapidly under S_N1 conditions?

a. CH_3OH **b.** CH_3CH_2OH **c.** $(CH_3)_2CHCH_2OH$
***d.** $(CH_3)_3COH$ **e.** $CH_3CH_2CH_2OH$

7.24. Which statement is false? *Tert*-Butyl alcohol reacts

a. with HCl to give 2-methylpropene by an E1 mechanism.
b. with HCl to give 2-chloro-2-methylpropane by an S_N1 mechanism.
***c.** with HCl and HBr at very different rates.
d. with HCl or HBr to give a carbocation intermediate.
e. with HCl to give both 2-methylpropene and 2-chloro-2-methylpropane.

7.25. The rate-determining step in the following reaction is:

$$(CH_3)_3C{-}OH + HBr \longrightarrow (CH_3)_3C{-}Br + H_2O$$

a. protonation of the alcohol.
b. ionization of the alcohol to give a carbocation.
*c. loss of water from the protonated alcohol to give a carbocation.
d. capture of a carbocation by bromide ion.
e. displacement of water from the protonated alcohol by bromide ion.

7.26. The rate-determining step in the following reaction is:

$$CH_3CH_2CH_2CH_2OH + HBr \xrightarrow{\text{heat}} CH_3CH_2CH_2CH_2Br + H_2O$$

a. protonation of the alcohol
b. ionization of the alcohol to give a carbocation.
c. loss of water from the protonated alcohol to give a carbocation
d. capture of a carbocation by bromide ion.
*e. displacement of water from the protonated alcohol by bromide ion.

Reactions

7.27. What type of compound is formed when a secondary (2°) alcohol is treated with Jones' reagent?

a. an alkene **b.** an alkyne **c.** an aldehyde ***d.** a ketone **e.** an acid

7.28. When an alcohol reacts with an alkali metal like Na, the product formed is a(n):

a. alkene ***b.** alkoxide **c.** acetylide
d. alkane **e.** hydroxide **f.** alkyne

7.29. Which reagents would you use to accomplish the following transformation?

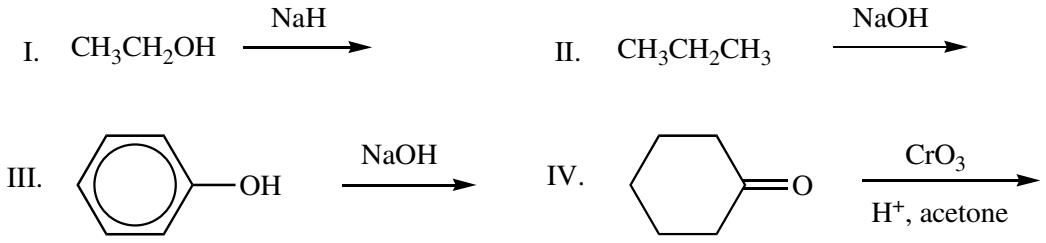
$$CH_3(CH_2)_6CH_2OH \longrightarrow CH_3(CH_2)_6CO_2H$$

a. H_2SO_4, H_2O, acetone ***b.** CrO_3, H_2SO_4, acetone **c.** PCC/CH_2Cl_2
d. Zn, HCl, acetone **e.** H_2, Pd, acetone

7.30. What is the major product from the E1 dehydration of 2-methyl-2-pentanol?

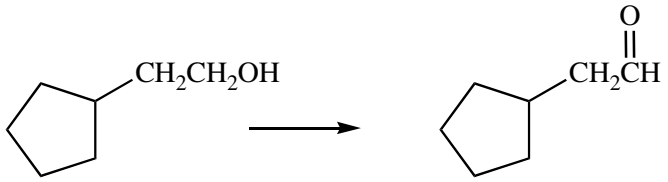
a. 4-methyl-1-pentene **b.** 4-methyl-3-pentene
***c.** 2-methyl-2-pentene **d.** 2-methyl-1-pentene
e. 4-methyl-2-pentene

7.31. Which of the following mixtures would NOT react?



a. I **b.** II **c.** III **d.** IV ***e.** II and IV

7.32. What reagents would accomplish the following transformation?



a. 1. PCl_3 2. H_3O^+ **b.** CrO_3, H^+ in acetone ***c.** PCC, CH_2Cl_2
d. 1. Na 2. CH_3OH **e.** none of the above

7.33. Acid-catalyzed dehydration of 3-methyl-3-hexanol can give the following number of alkenes (including stereoisomers):

a. 2 **b.** 3 **c.** 4 ***d.** 5 **e.** 6

7.34. Cyclohexanol and phenol react similarly toward

***a.** sodium hydride. **b.** $FeBr_3$, Br_2. **c.** conc. H_2SO_4, heat.
d. PCl_3. **e.** $SOCl_2$.

7.35. Oxidation of secondary alcohols with Jones' reagent (CrO_3, H^+, acetone) gives

a. carboxylic acids. **b.** aldehydes. ***c.** ketones.
d. chromate esters. **e.** tertiary alcohols.

7.36. Which of the following reagents will oxidize primary alcohols to carboxylic acids?

1. CrO_3, H_2SO_4
2. PCC
3. PCl_3
4. $SOCl_2$

***a.** only 1 **b.** only 2 **c.** only 3 **d.** only 4 **e.** 1 and 2

7.37. Which of the following reagents will oxidize secondary alcohols to ketones?

1. CrO_3, H_2SO_4
2. PCC
3. PCl_3
4. $SOCl_2$

a. only 1 **b.** only 2 **c.** only 3 **d.** only 4 ***e.** 1 and 2

7.38. The reaction of phenol with bromine gives

a. hydroquinone. **b.** 1,4-benzoquinone.
***c.** 2,4,6-tribromophenol. **d.** 3,5-dibromophenol. **e.** bromobenzene.

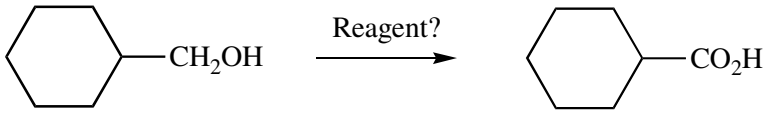
7.39. Which reagent or reagents can be used irreversibly to accomplish the following transformation:

$$CH_3CH_2OH \longrightarrow CH_3CH_2O^- Na^+$$

1. NaH
2. Na
3. NaOH

a. only 1 **b.** only 2 **c.** only 3
***d.** 1 and 2 **e.** 1, 2, and 3

7.40. Which reagent will accomplish the following transformation?



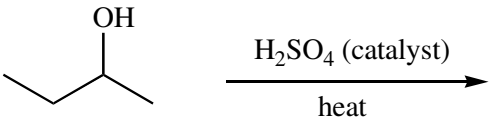
a. pyridinium chlorochromate ***b.** $K_2Cr_2O_7$, H_2SO_4, H_2O
c. H_2O_2, NaOH, H_2O **d.** $Ag(NH_3)_2^+$, NaOH (Tollen's reagent)
e. all of the above

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

$$CH_3CH_2CH_2CH_2SH \xrightarrow[2.\ CH_3I\ (1\ \text{equivalent})]{1.\ KOH\ (1\ \text{equivalent})}$$

***a.** $CH_3CH_2CH_2CH_2SCH_3$ **b.** $CH_3CH_2CH_2CH_2OCH_3$
c. $(CH_3CH_2CH_2CH_2S)_2$ **d.** $CH_3CH_2CH_2CH_2OH$
e. $CH_3CH_2CH_2CH_2S^+(CH_3)_2\ I^-$

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



a. $CH_3CH_2CH{=}CH_2$ **b.** *cis*-$CH_3CH{=}CHCH_3$
***c.** *trans*-$CH_3CH{=}CHCH_3$ **d.** $(CH_3)_2C{=}CH_2$
e. none of the above

Chapter 8
Ethers and Epoxides

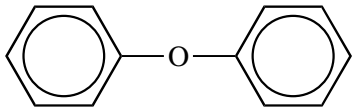
Structure and Nomenclature of Ethers

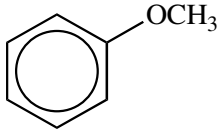
8.1. What is a correct name for $CH_3CH_2OCH_3$?

a. ethyl ether **b.** dimethyl ether ***c.** methoxyethane
d. ethoxymethane **e.** propane

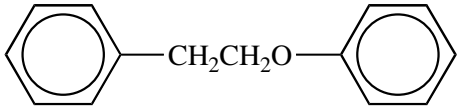
8.2. Which of the following molecules is the correct structure for dibenzyl ether?

a. $CH_3CH_2OCH_2CH_3$

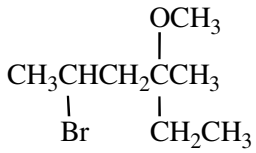
b. 

c. 

***d.** 

e. 

8.3. What is the IUPAC name for the following molecule?



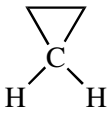
a. 2-bromo-4-ethyl-4-methoxypentane
b. 4-bromo-2-ethyl-2-methoxypentane
***c.** 2-bromo-4-methoxy-4-methylhexane
d. 2-bromo-3-methoxy-3methyl-hexane
e. ethyl methyl propyl ether

8.4. Which of the following molecules is named oxirane?

***a.** 

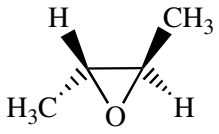
b. 

c. 

d. 

e. $CH_3CH_2OCH_3$

8.5. What is the correct IUPAC name for the following molecule?

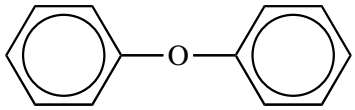


a. 1,2-dimethyloxirane ***b.** *trans*-1,2-dimethyloxirane **c.** 2-butene oxide
d. *cis*-1,2-dimethyloxirane **e.** oxobutane

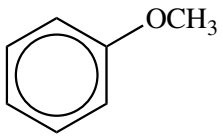
8.6. Which of the following molecules is correctly named diphenyl ether?

a. $CH_3CH_2OCH_2CH_3$

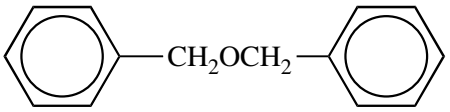
***b.**



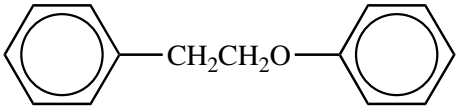
c.



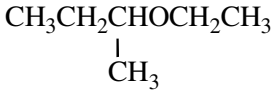
d.



e.

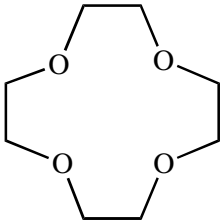


8.7. What is a name for the following molecule?



a. 3-ethoxy-3-methylpropane **b.** ethyl isobutyl ether
c. butyl ethyl ether ***d.** 2-ethoxybutane
e. 3-ethoxybutane

8.8. What is the correct name for the following crown ether?



a. [8]crown-4 ***b.** [12]crown-4 **c.** [4]crown-4
d. [15]crown-5 **e.** [18]crown-6

8.9. A crown ether named [18]crown-6 has a total of __ carbons and _____ oxygens .

a. 18, 6 **b.** 6, 18 **c.** 24, 6
d. 6, 24 ***e.** 12, 6

8.10. The formula for 2-ethoxybutane is

***a.** $CH_3CH_2O\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_3$

b. $CH_3CH_2OCH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3$

c. $CH_3\underset{\displaystyle OCH_3}{\underset{|}{C}}HCH_2CH_3$

d. $CH_3CH_2OCH_2CH_2CH_2CH_3$

e. $CH_3O\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_3$

Properties of Ethers

8.11. Which one of the following molecules has the highest boiling point?

a. 3-methoxy-1-propanol **b.** 1,2-dimethoxyethane ***c.** 1,4-butanediol
d. 1,1-dimethoxyethane **e.** 2-methoxy-1-propanol

Preparation and Reaction of Grignard Reagents

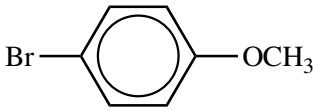
8.12. Which of the following is a Grignard reagent?

***a.** CH_3MgCl **b.** CH_3Li **c.** $(CH_3)_2CuLi$
d. CH_3Na **e.** $(CH_3)_2Zn$

8.13. Which reaction will yield CH_3CH_2D?

a. $CH_3CH_3 + D_2O$ ***b.** $CH_3CH_2MgCl + D_2O$
c. $CH_3CH_2OLi + D_2O$ **d.** $CH_3CH_2OH + D_2O$
e. more than one or these

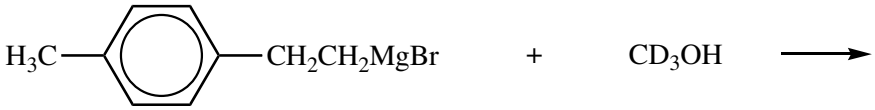
8.14. Starting with *p*-bromoanisole (*p*-bromophenyl methyl ether), what sequence of reactions will produce *p*-deuterioanisole?



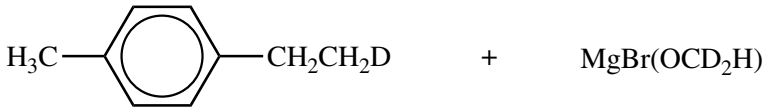
p-bromoanisole

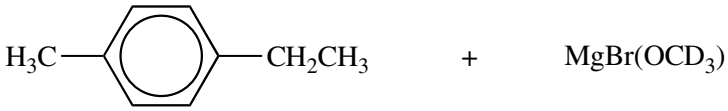
a. 1. D_2O 2. Br_2, $AlBr_3$ ***b.** 1. Mg, ether 2. D_2O
c. 1. D_2O 2. Mg, ether **d.** 1. H_2SO_4, 2. Mg, ether 3. D_2O
e. 1. Br_2, $AlBr_3$, 2. Mg, ether, 3. D_2O

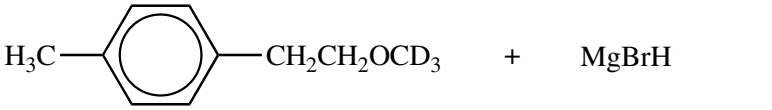
8.15. The products of

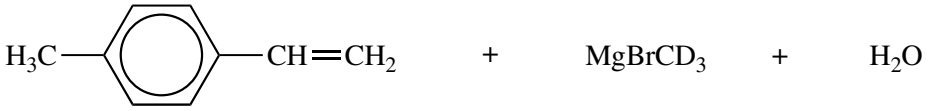


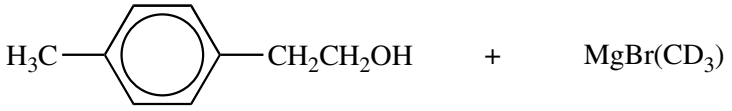
are:

a. 

***b.** 

c. 

d. 

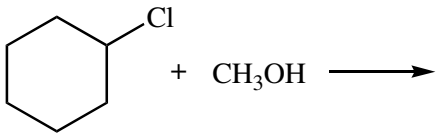
e. 

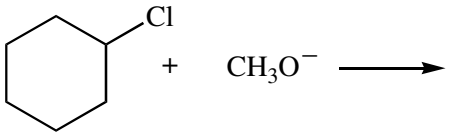
Preparation of Ethers

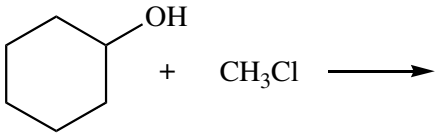
8.16. The synthesis of dipropyl ether can be accomplished using 1-propanol. What reactants and conditions are necessary for this to occur?

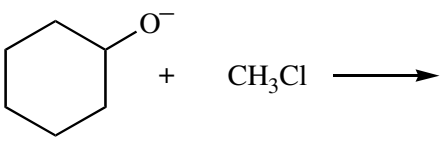
a. Na and 180° **b.** PBr_3 and 140° ***c.** H_2SO_4 and 140°
d. Zn and H^+ **e.** PCC and 180°

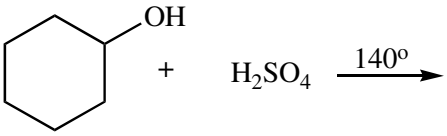
8.17. The best Williamson synthesis of cyclohexyl methyl ether involves the following reaction:

a. 

b. 

c. 

***d.** 

e. 

8.18. What alkene reacts with methanol in an acid catalyzed reaction to produce *t*-butyl methyl ether?

a. ethylene ***b.** 2-methylpropene **c.** 2-butene
d. propene **e.** 1-butene

8.19. The best route to $CH_3OC(CH_3)_3$ is

a. $CH_3O^- Na^+ + (CH_3)_3CBr \longrightarrow$

***b.** $CH_3OH + CH_2{=}C(CH_3)_2 \xrightarrow{H^+}$

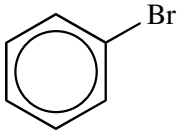
c. $(CH_3)CMgBr + CH_3OH \longrightarrow$

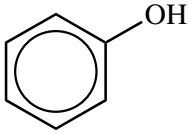
d. $CH_3OMgBr + (CH_3)_3C{-}I \longrightarrow$

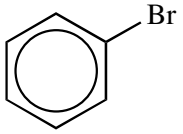
e. $CH_3MgBr + (CH_3)_3COH \longrightarrow$

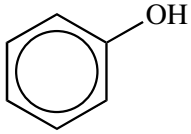
Behavior of Ethers in Acids

8.20. When anisole (methyl phenyl ether) is treated with concentrated HBr, which of the following products are produced?

I. $CH_3OH +$ 

II. $CH_3OH +$ 

III. $CH_3Br +$ 

IV. $CH_3Br +$ 

a. I **b.** II **c.** III ***d.** IV **e.** I and IV

8.21. The mechanism by which ethers are cleaved in concentrated HI is:

a. S_N1 ***b.** S_N2 **c.** E1
d. E2 **e.** none of these

8.22. Which of the following ethers will cleave the fastest with H_2O and H^+ ?

a. CH_3OCH_3 **b.** CH_3CHOCH_3 (with CH_3 below) **c.** $CH_3CH_2CH_2OCH_2CH_2CH_3$

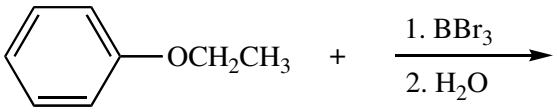
***d.** CH_3COCH_3 (with CH_3 above and below) **e.** $CH_3CHCH_2OCH_3$ (with CH_3 below)

8.23. Which of following ethers will cleave by an S_N1 mechanism?

a. CH_3OCH_3 **b.** CH_3CHOCH_3 (CH$_3$ below) **c.** $CH_3CH_2CH_2OCH_2CH_2CH_3$

***d.** CH_3COCH_3 (CH$_3$ above and below) **e.** $CH_3CHCH_2OCH_3$ (CH$_3$ below)

8.24. The organic products of the reaction



are:

a. ethanol and bromobenzene. **b.** ethyl bromide and bromobenzene.
c. ethanol and phenol. ***d.** ethyl bromide and phenol.
e. ethylene oxide and phenol.

Preparation and Reactions of Epoxides

8.25. Which of the following molecules is classified as an organic peroxy acid?

a. $HOCH_2CH_2OH$ **b.** CH_3CO_2H **c.** CH_3CHO

d. CH_3CCH_3 (O above) ***e.** CH_3CO_3H

8.26. The first step in the mechanism of acid catalyzed ring opening of oxirane is:

***a.** protonation of the oxygen in the oxirane.
b. anion attack of the carbon in the oxirane.
c. cation attack of the carbon in the oxirane.
d. formation of a stable carbocation.
e. none of the above.

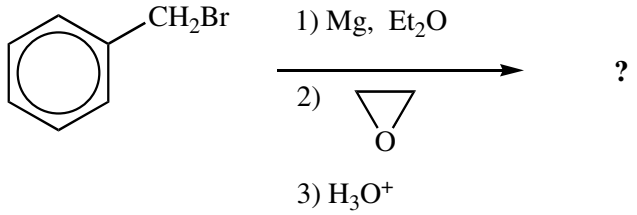
8.27. When cyclohexene is treated with peroxyacetic acid, the product that forms is:

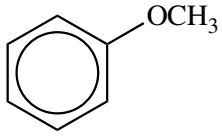
a. cyclohexanediol **b.** 1,2-cyclohexanediol **c.** hexanol
***d.** cyclohexene oxide **e.** dicyclohexyl ether

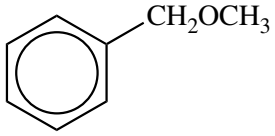
8.28. The correct structure for peroxyacetic acid is:

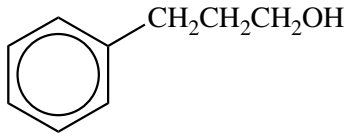
a. CH_3CO_2H **b.** $CH_3OCH_2CH_2OH$ ***c.** CH_3CO_3H
d. $CH_3OCH_2CH_2CO_2H$ **e.** CH_3OOCH_3

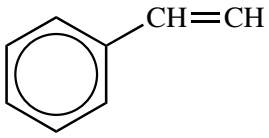
8.29. What is the final product of the following sequence of reactions?

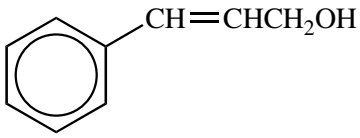


a. 

b. 

***c.** 

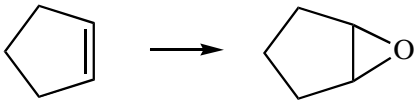
d. 

e. 

8.30. Which of the following statements about ethylene oxide is false?

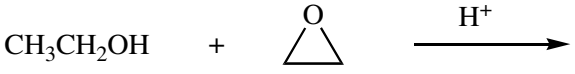
***a.** Adds HBr according to Markovnikov's rule.
b. Can act as a Lewis base.
c. Reacts with Grignard reagents to give primary alcohols.
d. Can be made from ethene, oxygen, and a catalyst.
e. Can be hydrated to ethylene glycol.

8.31. Which reagent will accomplish the following reaction?



a. NaOH ***b.** CH_3CO_3H **c.** H_2O, H_2SO_4
d. (a) BH_3 (b) NaOH, H_2O_2 **e.** CH_3CO_2H

8.32. The product of the reaction



is:

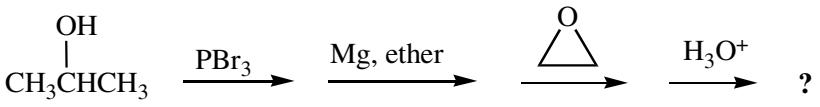
a. $CH_3CH_2CH_2CH_3$.
***b.** $CH_3CH_2OCH_2CH_2OH$.
c. $CH_3CH_2OCH_2CH_2OCH_2CH_3$.
d. $CH_3CH_2OCH_2CH_2CH_2OH$.
e. none of the above.
f. all of the above.

Miscellaneous

8.33. 1-Hexanol and propyl ether are examples of:

a. enantiomers **b.** diastereomers **c.** stereoisomers
***d.** constitutional isomers **e.** none of these

8.34. What is the final product in the following reaction sequence?



a. $CH_3CHOCH_2CH_2OH$ (CH3 branch) **b.** $CH_3CHCH_2CH_2Br$ (CH3 branch) ***c.** $CH_3CHCH_2CH_2OH$ (CH3 branch)

d. $CH_3CHOCH_2CH_3$ (CH3 branch) **e.** none of these

8.35. Isopropyl bromide reacts with Li to give:

a. propene **b.** propyllithium **c.** propane
***d.** isopropyllithium **e.** butane

8.36. Which of the following ethers are unsymmetrical?

a. $CH_3CH_2OCH_2CH_3$ **b.** $(CH_3)_2CHOCH_2CH(CH_3)_2$ **c.** CH_3OCH_3
d. $CH_3OCH_2CH_3$ ***e.** both b and d

8.37. A reaction that would give *n*-butyllithium is

a. $CH_3CH_2CH_2CH_3 + Li$ ***b.** $CH_3CH_2CH_2CH_2Br + 2\ Li$
c. $CH_3CH_2CH_2CH_2Br + LiBr$ **d.** $CH_3CH_2CH_2CH_2OH + Li$
e. $CH_3CH_2CH_2CH_3 + CH_3Li$

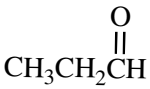
8.38. Adding Br_2 in H_2O will distinguish which of following pairs of compounds?

a. diisopropyl ether and hexane
***b.** ethyl phenyl ether and allyl phenyl ether
c. 1-butanol and methyl propyl ether
d. diethyl ether and ethanol
e. toluene and anisole

Chapter 9
Aldehydes and Ketones

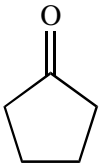
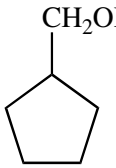
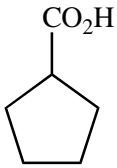
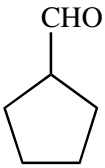
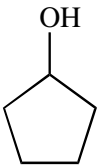
Nomenclature of Aldehydes, Ketones and Derivatives

9.1. The common name for the following molecule is:



a. acetaldehyde ***b.** propionaldehyde **c.** butanal
d. propyl aldehyde **e.** ethylmethanal

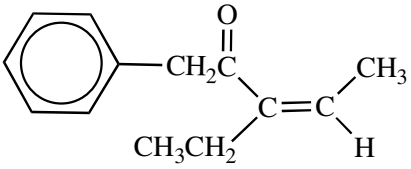
9.2. What is the structure of cyclopentanecarbaldehyde?

a.  **b.**  **c.**  ***d.**  **e.** 

9.3. The IUPAC name for acetone is

a. butanone **b.** 2-pentanone **c.** 3-pentanone
***d.** propanone **e.** acetophenone

9.4. The IUPAC name for the following molecule is:

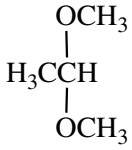


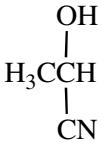
a. 3-ethyl-1-phenyl-3-pentenone **b.** 3-ethyl-5-phenyl-2-penten-4-one
c. allyl benzyl ketone **d.** (*E*)-3-ethyl-1-phenyl-3-penten-2-one
***e.** (*Z*)-3-ethyl-1-phenyl-3-penten-2-one

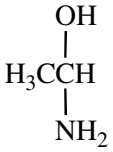
9.5. What is the class of compound produced from the reaction of a ketone with hydrazine?

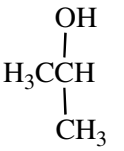
a. oxime **b.** amide ***c.** hydrazone
d. semicarbazone **e.** imide

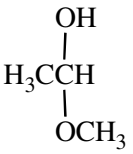
9.6. Which of the following molecules is a hemiacetal?

a. 

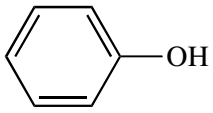
b. 

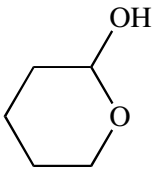
c. 

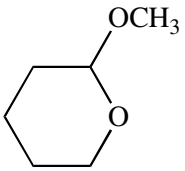
d. 

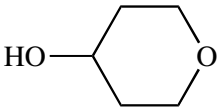
***e.** 

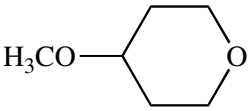
9.7. Which of the following compounds is a hemiacetal?

a. 

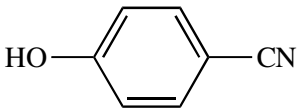
***b.** 

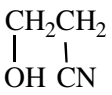
c. 

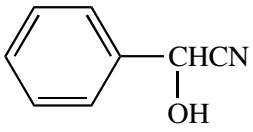
d. 

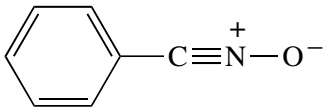
e. 

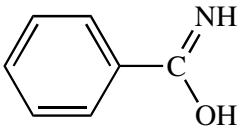
9.8. Which of the following compounds is a cyanohydrin?

a. 

b. 

***c.** 

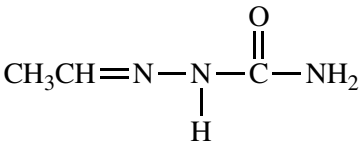
d. 

e. 

9. 9. Which of the following is a hydrazone?

***a.** $CH_3CH{=}N{-}NH_2$

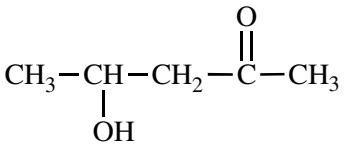
b. $CH_3CH{=}N{-}OH$

c. 

d. $CH_3CH_2{-}NH{-}NH_2$

e. $CH_3CH_2{-}NH{-}OH$

9.10. The name of



is:

a. 2-hydroxy-4-pentanone. **b.** 2-oxo-4-pentanol. **c.** 4-oxo-2-pentanol.
d. 1-acetyl-2-propanol. ***e.** 4-hydroxy-2-pentanone.

Properties of Aldehydes and Ketones

9.11. Which of the following molecules has the highest boiling point?

a. *o*-xylene **b.** *m*-xylene **c.** *p*-xylene
d. benzaldehyde ***e.** benzyl alcohol

9.12. Which of the following aldehydes can exist in equilibrium with a cyclic hemiacetal?

a. 4-pentenal **b.** 3-hydroxypropanal **c.** 2-hydroxybutanal
d. 3-hydroxybutanal ***e.** 4-hydroxybutanal

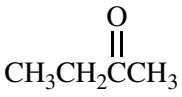
9.13. What class of compound most closely resembles an acetal in its reactivity with CH_3MgBr?

***a.** ethers **b.** aldehydes **c.** ketones **d.** alcohols **e.** thiols

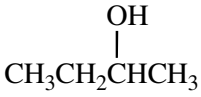
9.14. In a carbonyl group

a. the oxygen acts as a Lewis acid.
b. the C=O bond length is shortened due to resonance.
c. the carbon is sp^3 hybridized.
d. the carbon is nucleophilic and the oxygen is electrophilic.
***e.** the carbon is electrophilic and the oxygen is nucleophilic.

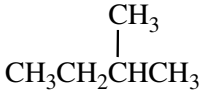
9.15. The expected order of boiling points of



1.



2.



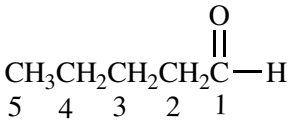
3.

is:

a. 3>2>1 ***b.** 2>1>3 **c.** 2>3>1
d. 1>2>3 **e.** 1>3>2

Enols/Enolates/Tautomerism

9.16. Which of the hydrogens in the following molecule are most acidic? The hydrogens on carbon

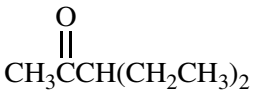


a. 1 ***b** 2 **c.** 3 **d.** 4 **e.** 5

9.17. The equilibrium that exists between the keto and enol forms of aldehydes and ketones is known as:

a. stereoisomerism **b.** configurational isomerism **c.** geometric isomerism
***d.** tautomerism **e.** positional isomerism

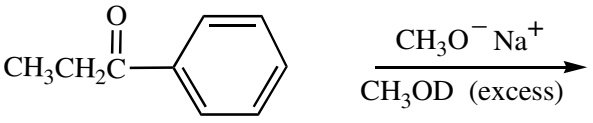
9.18. The number of α-hydrogens in



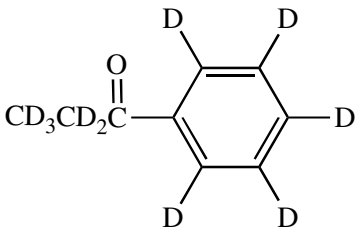
is

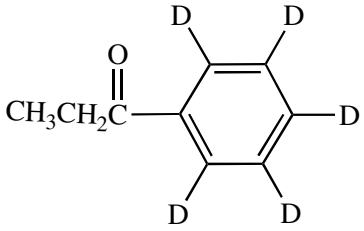
a. 1 **b.** 3 ***c.** 4 **d.** 8 **e.** 14

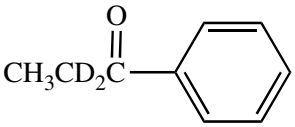
9.19. The predominant product from the reaction

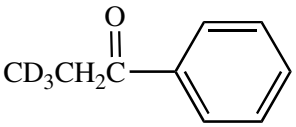


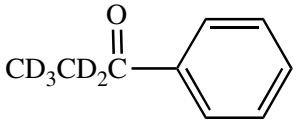
is:

a. 

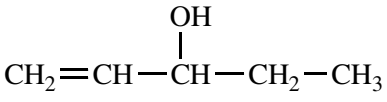
b. 

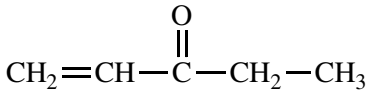
***c.** 

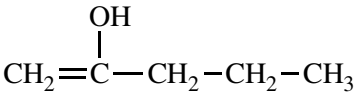
d. 

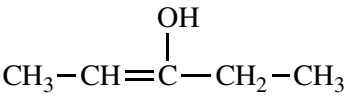
e. 

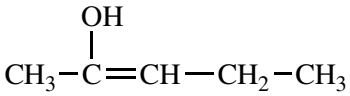
9.20. The enol tautomer of 3-pentanone is:

a. 

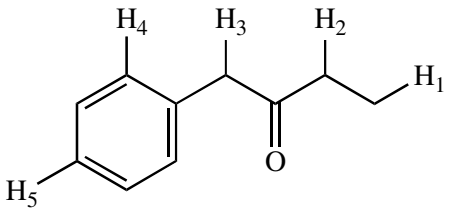
b. 

c. 

***d.** 

e. 

9.21. Which hydrogens in the following compound will be exchanged most rapidly for deuterium upon reaction with D_2O and NaOD?



a. H_1 **b.** H_2 ***c.** H_3 **d.** H_4 **e.** H_5

Reaction Mechanisms

9.22. In the mechanism for acid catalyzed hemiacetal formation, the first step is:

***a.** protonation of the carbonyl oxygen
b. nucleophilic attack at the carbonyl carbon
c. protonation of the oxygen of the alcohol
d. nucleophilic attack at the carbon of the alcohol
e. elimination of a water molecule

9.23. The *second* step in the base catalyzed aldol condensation is:

a. formation of the enolate ion
***b.** addition of an enolate to a carbonyl group
c. protonation of the alkoxide ion
d. protonation of the carbonyl oxygen
e. loss of a proton from the α carbon

9.24. What statement is *false* relative to the nucleophilic additions?

a. When a weak nucleophile is present, the reaction can be catalyzed by acid.
b. The nucleophile attacks the trigonal carbon of the carbonyl group.
***c.** Ketones are more reactive than aldehydes.
d. Nucleophiles that add irreversibly are poor leaving groups.
e. Nucleophiles can be classified as those that add reversibly to carbonyl compounds and those that add irreversibly.

9.25. Which statement about the mechanism of imine formation from a primary amine and an aldehyde or ketone is false?

a. The first steps involve addition of the amine to the carbonyl carbon to form a tetrahedral intermediate.
b. The last steps involve elimination of water to form a carbon-nitrogen p-bond.
c. All steps are reversible.
***d.** The reaction involves S_N2 displacement of the carbonyl oxygen by the amine nitrogen.
e. The reaction does not require a strong acid catalyst.

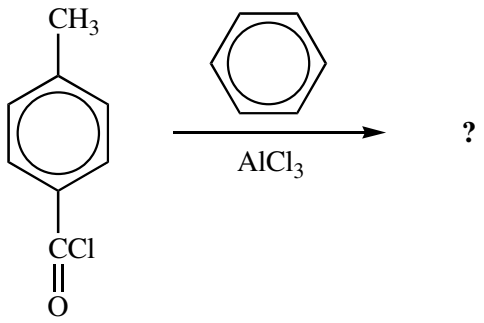
9.26. Which of the following nucleophiles add reversibly to a carbonyl group?

^-CN	H_2O	$^-CH_3$	H^-
I	II	III	IV

a. I, II and IV **b.** II ***c.** I and II
d. III and IV **e.** I, II, III and IV

Reactions

9.27. What type of compound is produced from the following reaction?



a. an amide **b.** an alcohol **c.** an acid **d.** an aldehyde ***e.** a ketone

9.28. An oxime can be produced by the reaction of an aldehyde and:

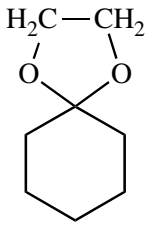
***a.** hydroxylamine **b.** hydrazine **c.** methylamine
d. phenylhydrazine **e.** semicarbazide

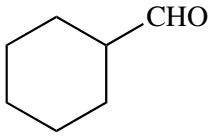
9.29. Which of the following compounds will NOT act as a nucleophile in an Aldol reaction?

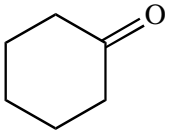
a. CH_3CHO **b.** $CH_3\overset{\overset{O}{\|}}{C}CH_3$ **c.** $(CH_3)_3\overset{\overset{O}{\|}}{C}C(CH_3)_3$

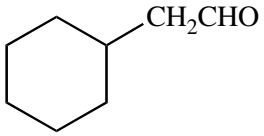
d. HCHO ***e.** c and d

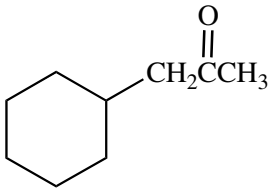
9.30. What reaction will produce the following product?

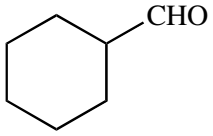


a.  + $HOCH_2CH_2OH$ $\xrightarrow{H^+}$

***b.**  + $HOCH_2CH_2OH$ $\xrightarrow{H^+}$

c.  + $HOCH_2CH_2OH$ $\xrightarrow{H^+}$

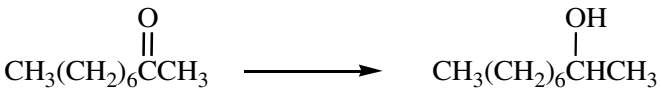
d.  + CH_3CH_2OH $\xrightarrow{H^+}$

e.  + CH_3CH_2OH $\xrightarrow{H^+}$

9.31. The reaction of a Grignard reagent with acetaldehyde followed by acid hydrolysis will produce what type of product?

a. a primary alcohol ***b.** a secondary alcohol **c.** a tertiary alcohol
d. an acid **e.** a ketone

9.32. Which reagents would you use to accomplish the following conversion?



a. $NaBH_4$, H_2O **b.** $LiAlH_4$, ether; then H_3O^+ **c.** H_2, Pt
***d.** all of these **e.** none of these

9.33. Which of the following reactions will produce a cyanohydrin?

a. $CH_3CH_2CCH_3$ (O) + N_2H_4 ⟶

***b.** $CH_3CH_2CCH_3$ (O) + HCN $\xrightarrow{KOH}$

c. $CH_3CH_2CCH_3$ (O) + CH_3MgCl $\xrightarrow{H_3O^+}$

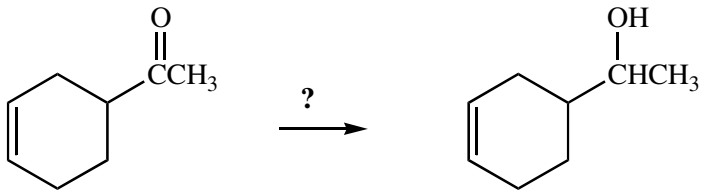
d. $CH_3CH_2CCH_3$ (O) + $NaBH_4$ ⟶

e. $CH_3CH_2CCH_3$ (O) + CH_3OH $\xrightarrow{HCl}$

9.34. What Grignard reagent and carbonyl compound react to give benzyl alcohol after treatment with aqueous acid?

***a.** phenyl magnesium bromide and formaldehyde
b. phenyl magnesium bromide and oxirane
c. benzaldehyde and methyl magnesium bromide
d. benzaldehyde and ethyl magnesium chloride
e. acetophenone and methyl magnesium chloride

9.35. Which reagent will accomplish the following transformation?



a. NaOH **b.** CrO_3, H_2SO_4 **c.** CH_3MgBr
***d.** $NaBH_4$ **e.** H_2, Pd

9.36. What is the structure of the aldol produced from reacting propanone with NaOH?

a. $CH_3CH_2CH_2CH_2CH_2CHO$

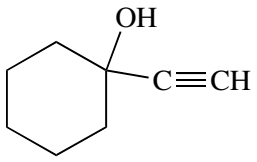
b. $CH_3C(CH_3)_2CH_2CHO$

c. $CH_3CH(OH)CH(CH_3)C(=O)CH_3$

d. $CH_3CH(OH)CH(CH_3)C(=O)CH_3$

***e.** $CH_3C(OH)(CH_3)CH_2C(=O)CH_3$

9.37. What reactants give the following molecule upon acid hydrolysis?



a. cyclohexyl magnesium bromide and acetaldehyde

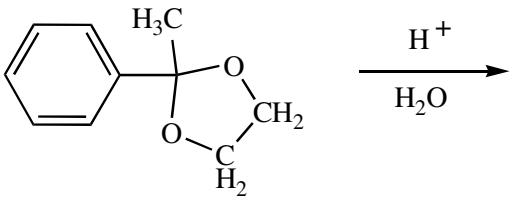
b. cyclohexanol and $HC{\equiv}C^{-}\ Na^{+}$

***c.** cyclohexanone and $HC{\equiv}C^{-}\ Na^{+}$

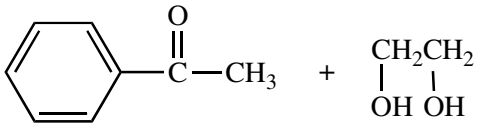
d. cyclohexanecarbaldehyde and $HC{\equiv}C^{-}\ Na^{+}$

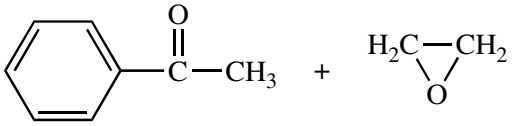
e. cyclohexanone and ethenyl magnesium bromide

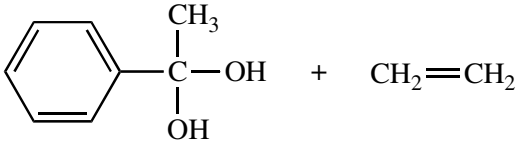
9.38. The products from

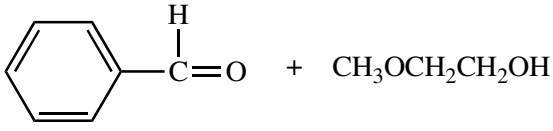


are

***a.** 

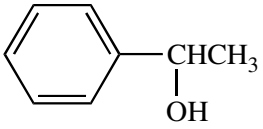
b. 

c. 

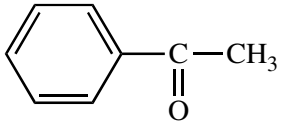
d. 

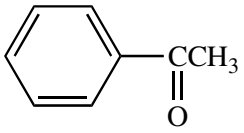
e. no reaction

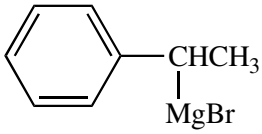
9.39.

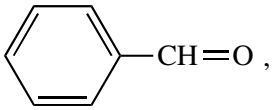


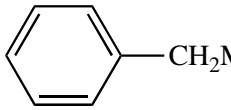
can be prepared from

a.  + HMgBr, then H_3O^+

b.  + CrO_3

c.  + H_2O

***d.** CH_3MgBr +  , then H_3O^+

e.  + $CH_2{=}O$, then H_3O^+

9.40. The product from

$$CH_3CH{=}CHCH{=}O \xrightarrow[2.\ H_3O^+]{1.\ NaBH_4}$$

is:

***a.** $CH_3CH{=}CHCH_2OH$

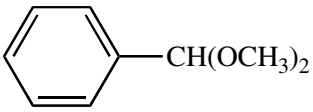
b. $CH_3CH_2CH_2CH{=}O$

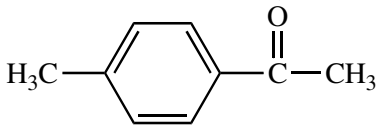
c. $CH_3CH_2CH_2CH_2OH$

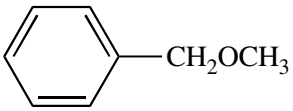
d. $CH_3CH{=}CHCO_2H$

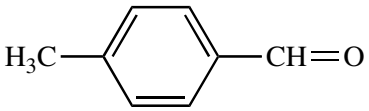
e. $CH_3CH_2CH_2CO_2H$

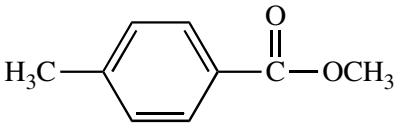
9.41. Which of the following compounds will give a positive silver mirror test (Tollens' test)?

a. 

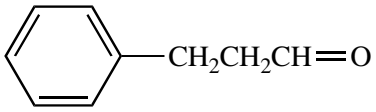
b. 

c. 

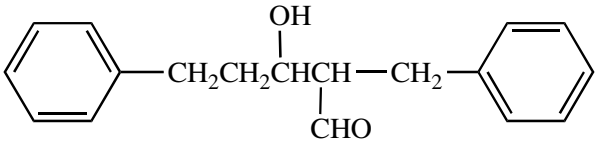
***d.** 

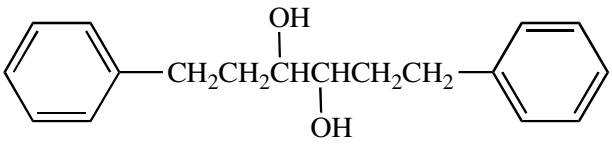
e. 

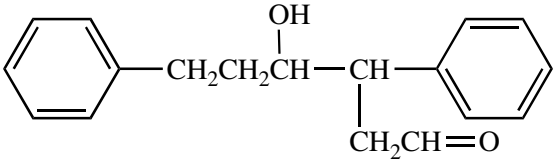
9.42. The aldol obtained by treating

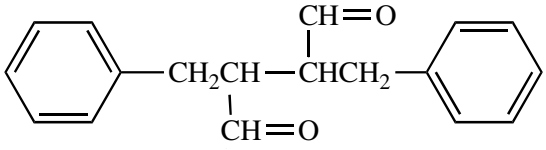


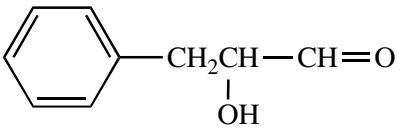
with base is:

***a.** 

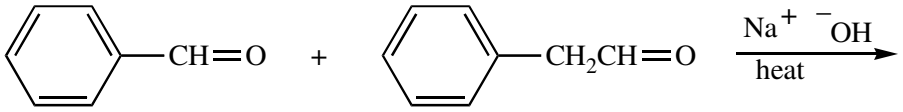
b. 

c. 

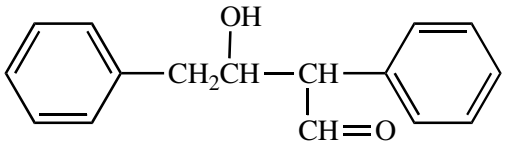
d. 

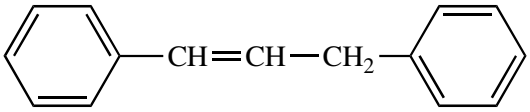
e. 

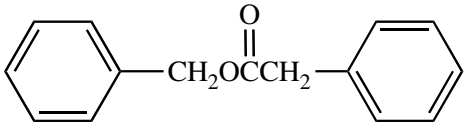
9.43. The major product obtained from

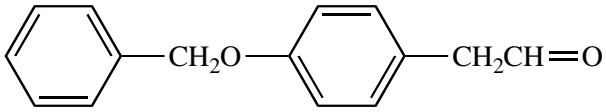


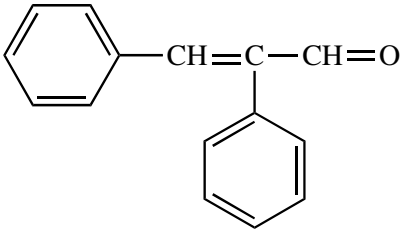
is:

a. 

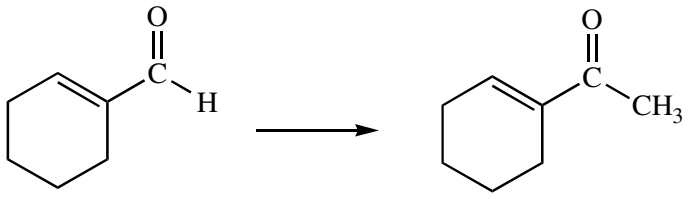
b. 

c. 

d. 

***e.** 

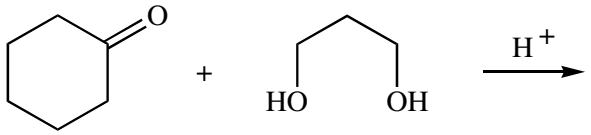
9.44. A reaction sequence that will accomplish the transformation



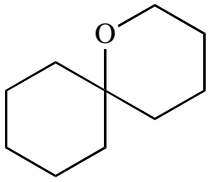
is:

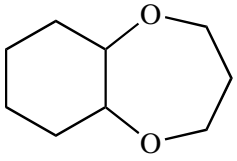
a. 1. CH_3MgBr 2. H_3O^+
***b.** 1. CH_3Li 2. H_3O^+ 3. CrO_3, H_2SO_4
c. 1. $LiAlH_4$ 2. H_3O^+ 3. CH_3MgBr
d. 1. H_2, Pd catalyst 2. CH_3MgBr 3. H_3O^+
e. 1. CrO_3, H_2SO_4 2. CH_3MgBr 3. H_3O^+

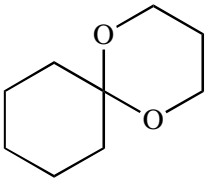
9.45. The organic product of the reaction

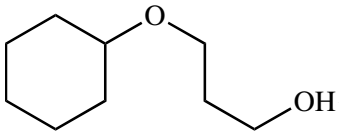


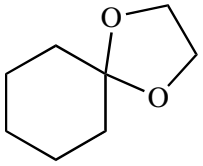
is

a. 

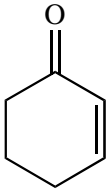
b. 

***c.** 

d. 

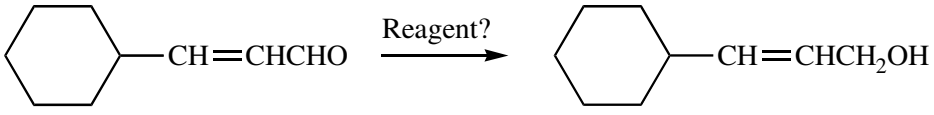
e. 

9.46. How many hydrogens in the following compound will be exchanged for deuterium upon reaction with D_2O and an acid catalyst?



a. 0 **b.** 2 **c.** 4 ***d.** 5 **e.** 8

9.47. Which reagent can be used to accomplish the following transformation?



a. pyridinium chlorochromate
***c.** $NaBH_4$
e. NaH
b. Tollens' reagent
d. H_2, Ni

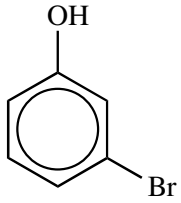
Chapter 10
Carboxylic Acids and Their Derivatives

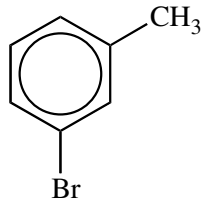
Nomenclature of Carboxylic Acids and Derivatives

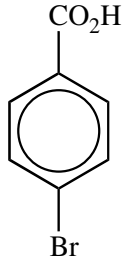
10.1. What is the *common* name for HCOOH?

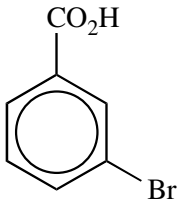
***a.** formic acid **b.** acetic acid **c.** propionic acid
d. oxalic acid **e.** malonic acid

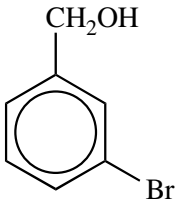
10.2. Which of the following represents *m*-bromobenzoic acid?

a. 

b. 

c. 

***d.** 

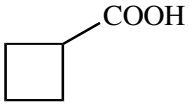
e. 

10.3. The IUPAC name for succinic acid is butanedioic acid. What is the structure of succinic acid?

a. $CH_3CH_2CH_2CO_2H$ **b.** $CH_3CH{=}CHCO_2H$ ***c.** $HO_2CCH_2CH_2CO_2H$

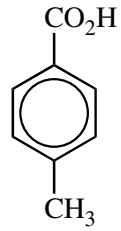
d. $CH_3CH_2CH_2CO_3H$ **e.** $HOCH_2CH_2CH_2CO_2H$

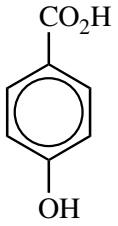
10.4. What is a correct name for the following structure?

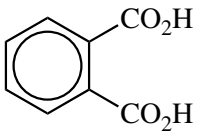


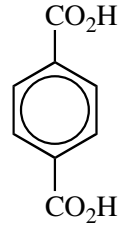
a. butanoic acid ***b.** cyclobutanecarboxylic acid
c. succinic acid **d.** cyclobutylacetic acid
e. formyl cyclobutane

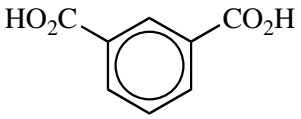
10.5. Which of the following carboxylic acids is terephthalic acid?

I 

II 

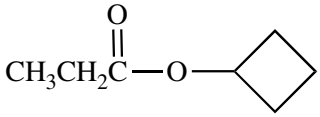
III 

IV 

V 

a. I **b.** II **c.** III ***d.** IV **e.** V

10.6. What is the IUPAC name of the following molecule?



***a.** cyclobutyl propanoate
b. cyclobutyl acetate
c. ethyl cyclobutanoate
d. propyl cyclobutanoate
e. propanoyl cyclobutyl ether

10.7. What is the name of the following molecule, $(CH_3)_2CHCONH_2$?

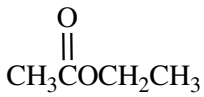
***a.** 2-methylpropanamide **b.** 3-methylpropanamide **c.** butyramide
d. α-methylbutyramide **e.** methylethanamide

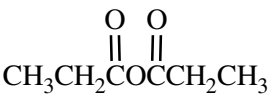
10.8. What is the IUPAC name of $CH_3CO_2CH(CH_3)_2$?

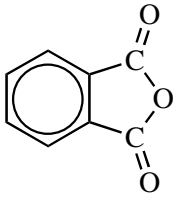
a. ethyl acetate **b.** propyl acetate ***c.** isopropyl ethanoate
d. ethyl propanoate **e.** dimethyl acetate

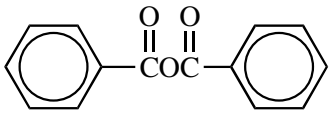
10.9. Which of the following molecules is not an anhydride?

a. 

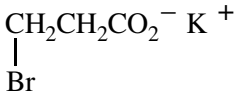
***b.** 

c. 

d. 

e. 

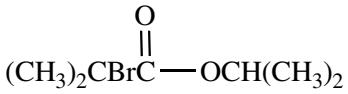
10.10. The IUPAC name for



is

***a.** potassium 3-bromopropanoate.
b. potassium 2-bromopropanoate.
c. potassium 3-bromopropionate.
d. potassium β-bromopropionate.
e. potassium γ-bromopropanoate.

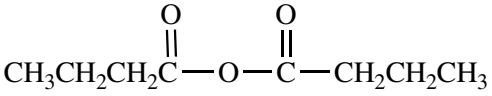
10.11. The IUPAC name for

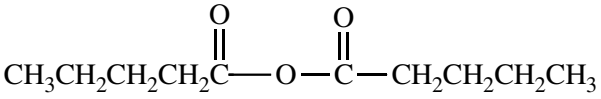


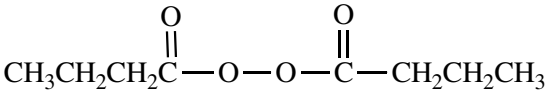
is

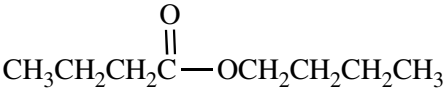
a. 2-bromoisopropyl isopropanoate.
b. isopropyl 2-bromoisobutanoate.
***c.** isopropyl 2-bromo-2-methylpropanoate.
d. 2-bromoisobutanoyl 2-propanoate.
e. isopropyl 2-bromo-3-methylbutanoate.

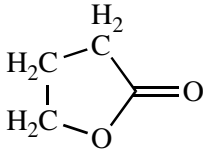
10.12. The formula for butanoic anhydride is

***a.**


b.


c.


d.


e.


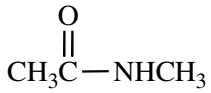
Properties of Carboxylic Acids and Derivatives

10.13. Which of the following molecules would have the highest boiling point?

***a.** CH_3CO_2H **b.** CH_3CH_2OH **c.** CH_3CHO

d. $CH_3CH{=}CH_2$ **e.** HCO_2H

10.14. Which of the following statements regarding



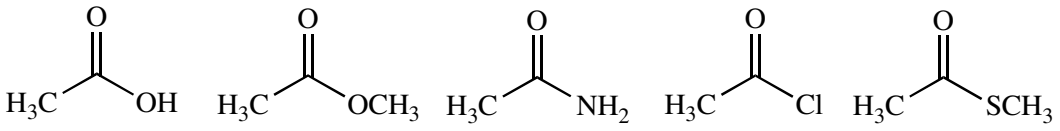
is false?

a. Rotation around the C—N bond is restricted.
b. The carbonyl group, NH group, and both methyl carbons lie in a plane.
***c.** The nitrogen is strongly basic.
d. The C—N bond is shorter than the C—N bond in amines.
e. The compound is named *N*-methylacetamide.

10.15. The boiling point of propanoic acid is higher than that of 1-butanol because:

a. propanoic acid has a higher molecular weight than 1-butanol.
b. propanoic acid is more soluble in water than 1-butanol.
c. propanoic acid is a better hydrogen bond donor than 1-butanol.
***d.** propanoic acid forms hydrogen bonded dimers and 1-butanol does not.
e. 1-butanol forms hydrogen bonded dimers and propanoic acid does not.

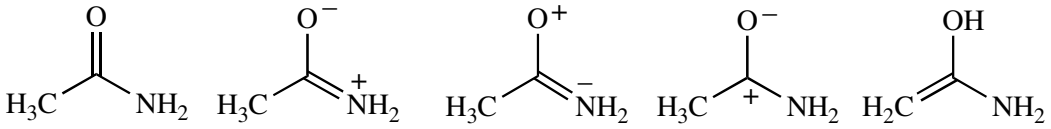
10.16. Which of the following compounds undergoes hydrolysis at the fastest rate upon reaction with sodium hydroxide in water?



I II III IV V

a. I **b.** II **c.** III ***d.** IV **e.** V

10.17. Which structure best describes the double bond character of the amide bond in acetamide?



I II III IV V

a. I ***b.** II **c.** III **d.** IV **e.** V

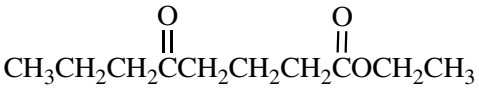
Acid-Base Chemistry

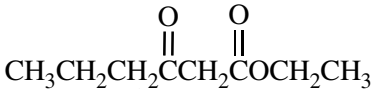
10.18. Which of the following molecules is the *weakest* acid?

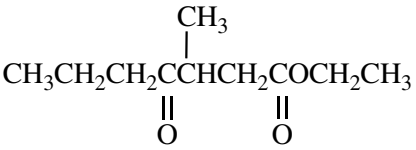
a. $CH_3CH_2CO_2H$ **b.** CH_3CHO **c.** CH_3CH_2OH

***d.** $CH_3C{\equiv}CH$ **e.** H_2O

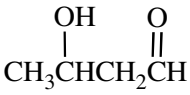
10.19. Which of the following molecules has the most acidic α-hydrogen?

a. 

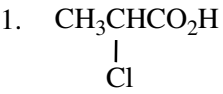
***b.** 

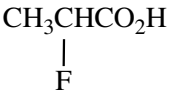
c. 

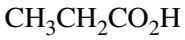
d. 

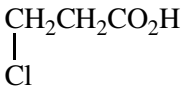
e. 

10.20. The expected order of decreasing acidity for

1. 

2. 

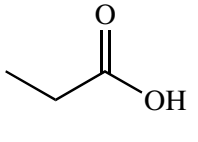
3. 

4. 

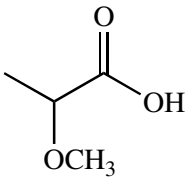
is:

a. 2 > 3 > 4 > 1 ***b.** 2 > 1 > 4 > 3 **c.** 1 > 2 > 3 > 4
d. 3 > 2 > 1 > 4 **e.** 1 > 3 > 4 > 2 **f.** 3 > 4 > 1 > 2

10.21. Rank the following according to their relative acidities



1



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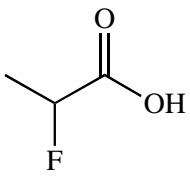
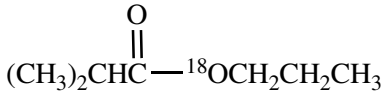


3

***a.** 3>2>1 **b.** 1>2>3 **c.** 2>3>1 **d.** 3>1>2 **e.** 2>1>3

Reaction Mechanisms

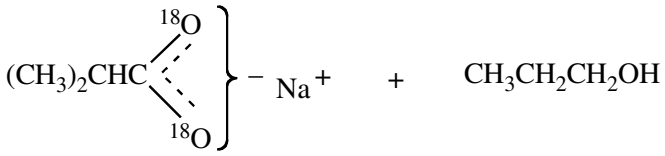
10.22. Saponification of

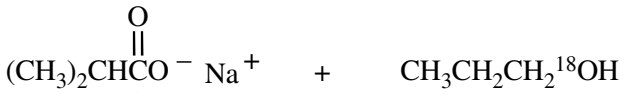


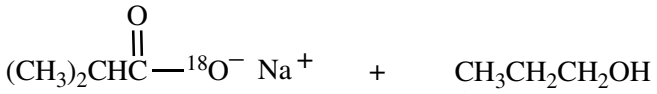
is expected to give

a. $(CH_3)_2CH—CH_2CH_2CH_3 \quad + \quad O{=}C{=}{}^{18}O$

b. $(CH_3)_2CHCH{=}O \quad + \quad CH_3CH_2CH_2{}^{18}OH$

c. 

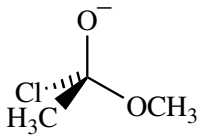
***d.** 

e. 

10.23. The mechanism of saponification is

a. nucleophilic aromatic substitution.
***b.** nucleophilic acyl substitution.
c. electrophilic aromatic substitution.
d. S_N2.
e. S_N1.

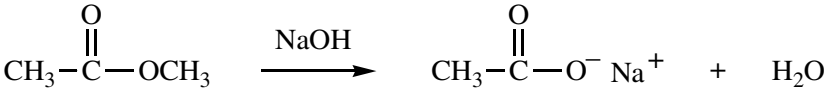
10.24. The following structure

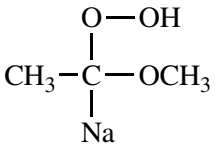


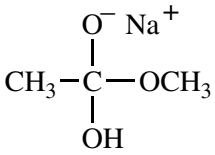
is an intermediate in the reaction of

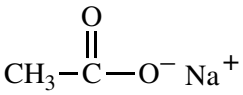
a. $CH_3CO_2CH_3$ with HCl.
***b.** CH_3COCl with $CH_3O^-\ Na^+$.
c. $CH_3CO_2CH_3$ with HOCl.
d. $CH_3CH(OCH_3)_2$ with Cl_2.
e. CH_3Cl with $(CH_3)_2C{=}O$.

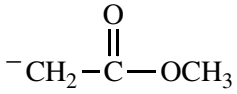
10.25. Which structure represents the tetrahedral intermediate in the following reaction?

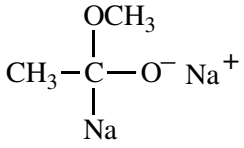


a. 

***b.** 

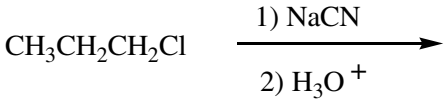
c. 

d. 

e. 

Reactions

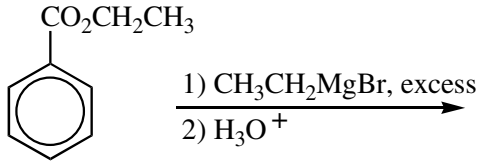
10.26. What is the product of the following reaction sequence?

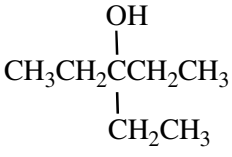


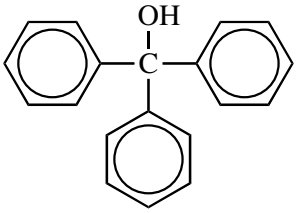
a. $CH_3CH_2CO_2H$ **b.** $CH_3CH_2CH_2CN$ ***c.** $CH_3CH_2CH_2CO_2H$

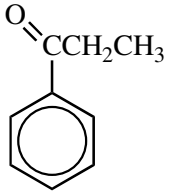
d. CH_3CH_2CN **e.** $CH_3CH_2CH_2CHO$

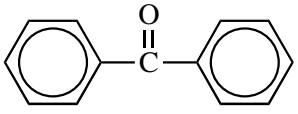
10.27. The product of the following reaction sequence is:

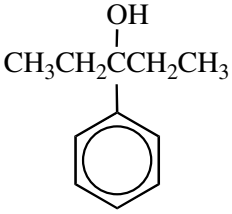


a. 

b. 

c. 

d. 

***e.** 

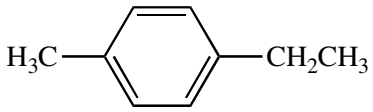
10.28. Acid chlorides react with alcohols to give:

***a.** esters **b.** ketones **c.** acetals **d.** amides **e.** acids

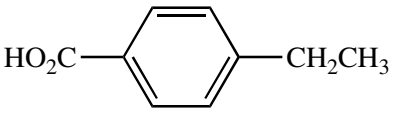
10.29. Which of the following carbonyl compounds reacts fastest with water?

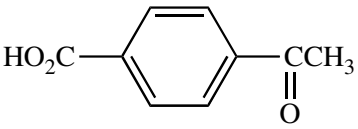
a. acid **b.** ester **c.** ketone ***d.** acid chloride **e.** amide

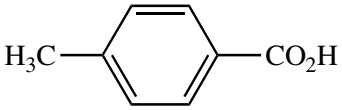
10.30. Oxidation of

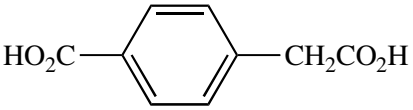


with $KMnO_4$ gives:

a.


b.


c.


d.


***e.**

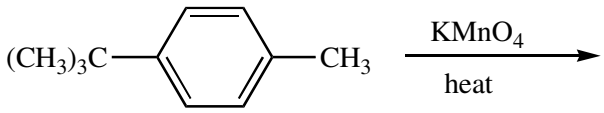

10.31. $(CH_3)_3CCO_2H$ can best be prepared by:

a. $(CH_3)_3CCHO \xrightarrow[2.\ H_3O^+]{1.\ LiAlH_4}$

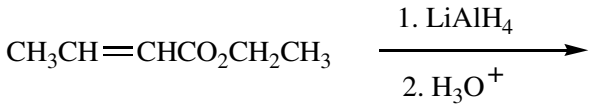
b. $(CH_3)_3CBr \xrightarrow[2.\ H_3O^+]{1.\ NaCN}$

c. $3\ CH_3Br + Br_3CCO_2H \xrightarrow{Na}$

***d.** $(CH_3)_3CBr \xrightarrow[3.\ H_3O^+]{1.\ Mg,\ Et_2O \quad 2.\ CO_2}$

e.


10.32. The product(s) from



are:

a. $CH_3CH{=}CHCO_2H + CH_3CH_2OH$

***b.** $CH_3CH{=}CHCH_2OH + CH_3CH_2OH$

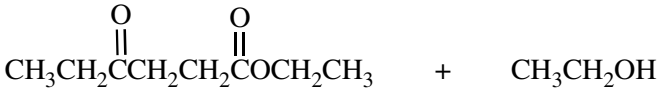
c. $CH_3CH_2CH_2CH_2OH + CH_3CH_2OH$

d. $CH_3CH_2CH_2CO_2CH_2CH_3$

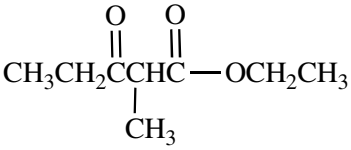
e. $CH_3CH{=}CHCO_2^-\ Li^+ + CH_3CH_2OH$

10.33. Treatment of $CH_3CH_2CO_2CH_2CH_3$ with $Na^+{}^-OCH_2CH_3$ gives

a. $CH_3CH_2CO_2^-\ Na^+ + CH_3CH_2OH$

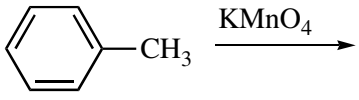
b.  $+ CH_3CH_2OH$

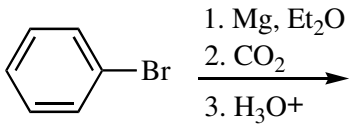
c.  $+ CH_3CH_2OH$

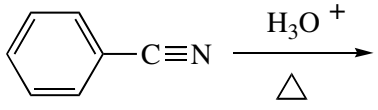
***d.**  $+ CH_3CH_2OH$

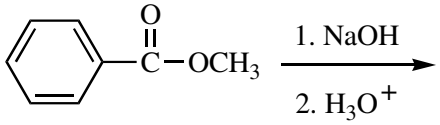
e. no reaction

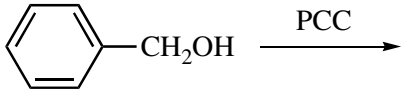
10.34. Benzoic acid cannot be prepared by which one of the following methods?

a. 

b. 

c. 

d. 

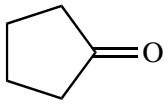
***e.** 

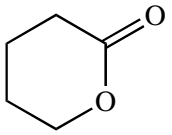
10.35. The expected product of the reaction

$$HOCH_2CH_2CH_2CH_2CO_2H \xrightarrow[\triangle]{H^+}$$

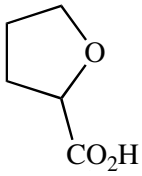
is:

a. $HOCH_2CH_2CH_2CH_2CH_2OH$

b. 

***c.** 

d. $HOCH_2CH_2CH_2CH_2-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_2CH_2CH_2CH_2OH$

e. 

10.36. The product(s) in the reaction

$$CH_3-CH_2-\overset{O}{\overset{\|}{C}}-NH_2 \xrightarrow{LiAlH_4}$$

are:

a. CH_3-CH_2-OH

***b.** $CH_3-CH_2-CH_2-NH_2$

c. $CH_3-CH_2-CH_2-OH \quad + \quad NH_3$

d. $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-\underset{\underset{H}{|}}{N}-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$

e. $CH_3-CH_2-C\equiv N$

10.37. Propyl ethanoate can be prepared by the reaction of

a. propanoic acid with ethanol.
b. ethanoic acid with isopropanol.
***c.** ethanoyl chloride with propanol.
d. propanoyl chloride with ethanol.
e. propanoic anhydride with ethanol.

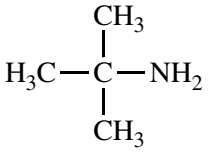
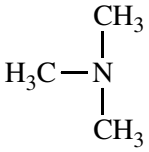
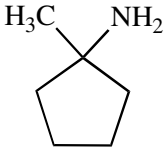
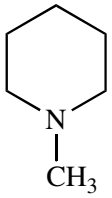
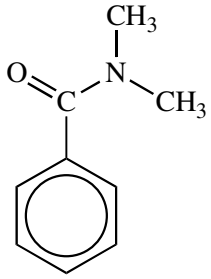
Chapter 11
Amines and Related Nitrogen Compounds

Nomenclature of Amines

11.1. *Sec*-butylamine is classified as a(n) _____ amine.

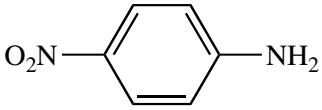
***a.** 1° **b.** 2° **c.** 3°
d. quaternary salt **e.** aromatic

11.2. Which of the following are tertiary amines?

1. 
2. 
3. 
4. 
5. 

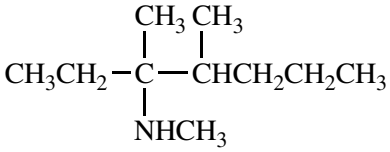
a. 1 and 3 **b.** only 5 **c.** 1, 2, 3, and 4
***d.** 2 and 4 **e.** 1 and 2

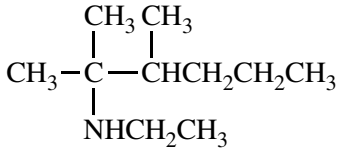
11.3. The structure below can be named in the following manner:

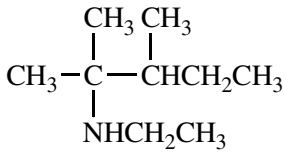


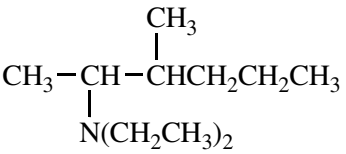
a. 4-nitrocyclohexanamine
b. *p*-nitroaniline
c. *o*-nitroaniline
d. 4-nitrobenzenamine
***e.** b or d

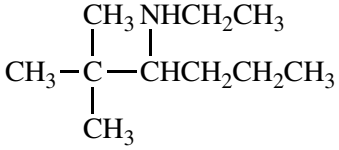
11.4. The structure that corresponds to *N*-ethyl-2,3-dimethyl-2-hexanamine is

a. 

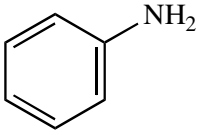
***b.** 

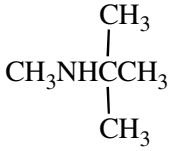
c. 

d. 

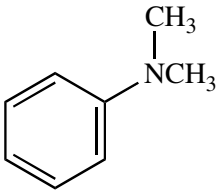
e. 

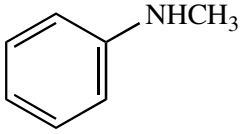
11.5. Which of the following compounds is a tertiary amine?

a. 

b. 

c. $CH_3CH_2NH_2$

***d.** 

e. 

Properties of Amines

11.6. Which of the following molecules has the highest boiling point?

a. methylamine **b.** ethane ***c.** methyl alcohol
d. dimethyl ether **e.** formaldehyde

11.7. To separate a mixture of *p*-toluidine and *p*-nitrotoluene dissolved in ether,

***a.** extract the ether solution with aqueous HCl and treat the water layer with aqueous NaOH.
b. extract the ether solution with aqueous NaOH and treat the water layer with aqueous HCl.
c. extract the ether solution with water and treat the water layer with aqueous NaOH.
d. extract the ether layer with aqueous HCl and treat the ether layer with aqueous NaOH.
e. extract the ether solution with aqueous HCl and treat the ether layer with aqueous HCl.

11.8 Which of the following statements about aliphatic amines is false?

a. The nitrogen in aliphatic amines is sp^3-hybridized.
***b.** Aliphatic 3° amines with three different groups on nitrogen can be resolved.
c. Aliphatic amines can be hydrogen bond donors.
d. Aliphatic amines can be hydrogen bond acceptors.
e. The non-bonded lone pair in an aliphatic amine is more basic than the non-bonded lone pairs in ethers.

Acid-Base Chemistry

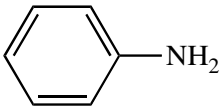
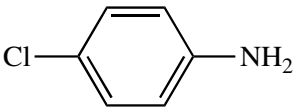
11.9. Which compound is the strongest base?

***a.** CH_3NH_2 **b.** CH_3CO_2H **c.** CH_3CHO **d.** CH_3OH **e.** $C_6H_5NH_2$

11.10. Which of the following amines is the most basic?

a. methylamine ***b.** dimethylamine **c.** ammonia
d. aniline **e.** N-methylaniline

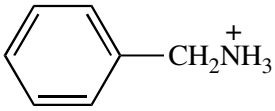
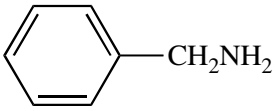
11.11. The order of decreasing pK_as of the corresponding ammonium ions of

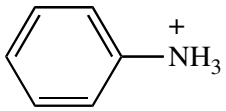
1. NH_3 2. CH_3NH_2 3.  4. 

is:

a. 1 > 2 > 3 > 4 **b.** 3 > 4 > 2 > 1 **c.** 4 > 3 > 2 > 1
***d.** 2 > 1 > 3 > 4 **e.** 4 > 3 > 1 > 2

11.12. The order of decreasing acidity of

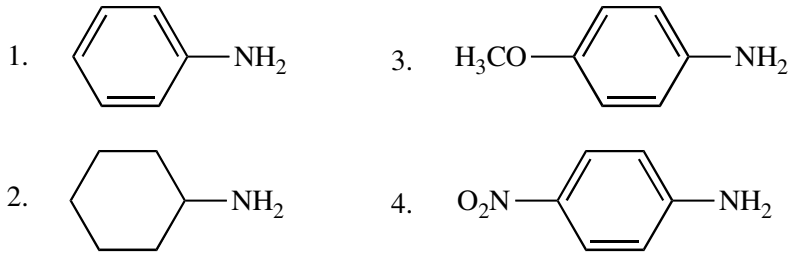
1.  2. 

3. 

is:

a. 1 > 2 > 3 ***b.** 3 > 1 > 2 **c.** 2 > 1 > 3
d. 3 > 2 > 1 **e.** 2 > 3 > 1

11.13. The order of increasing basicity of



is:

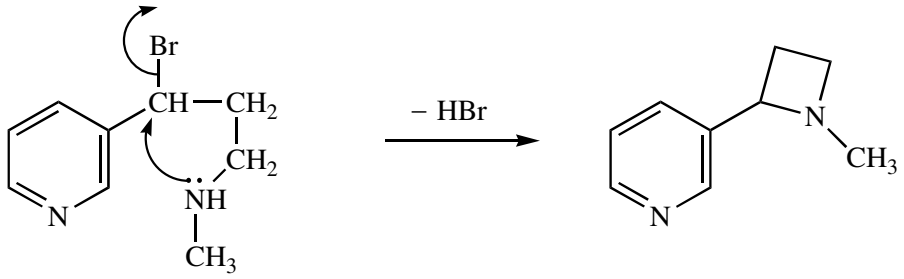
a. 1 < 2 < 3 < 4 **b.** 2 < 3 < 1 < 4 **c.** 4 < 3 < 2 < 1
d. 4 < 3 < 1 < 2 ***e.** 4 < 1 < 3 < 2

Reaction Mechanisms

11.14. When ammonia (NH_3) reacts with methyl bromide (CH_3Br) to give methylamine, the ammonia:

a. acts as an electrophile **b.** acts as a Lewis acid
c. acts as a Bronsted-Lowry acid **d.** acts as a Bronsted-Lowry base
***e.** acts as a nucleophile in an S_N2 reaction

11.15. What is the mechanism for the intramolecular alkylation shown below?



***a.** S_N2 **b.** S_N1
c. nucleophilic acyl substitution **d.** nucleophilic addition
e. electrophilic addition

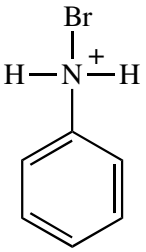
11.16. The mechanism by which acylation of an amine with an acid chloride takes place is:

***a.** nucleophilic acyl substitution **b.** electrophilic aromatic substitution
c. nucleophilic addition **d.** electrophilic addition
e. nucleophilic aromatic substitution

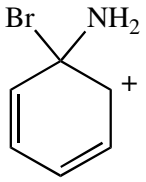
11.17. The alkylation of an amine with an alkyl halide takes place by the following mechanism:

a. S_N1 ***b.** S_N2 **c.** electrophilic addition
d. E1 **e.** E2

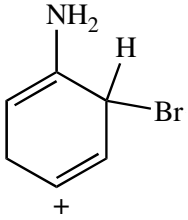
11.18. What structure represents a cationic intermediate in the electrophilic aromatic bromination of aniline?



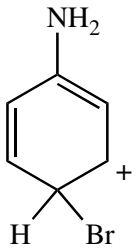
I



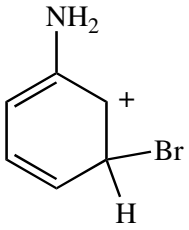
II



III



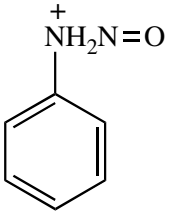
IV



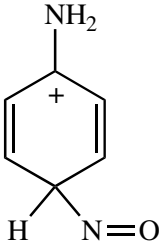
V

a. I **b.** II **c.** III ***d.** IV **e.** V

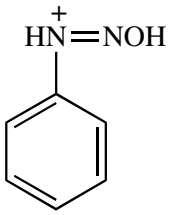
11.19. Which of the following is not an intermediate in the diazotization of aniline using nitrous acid?



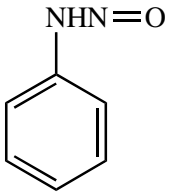
I



II



III

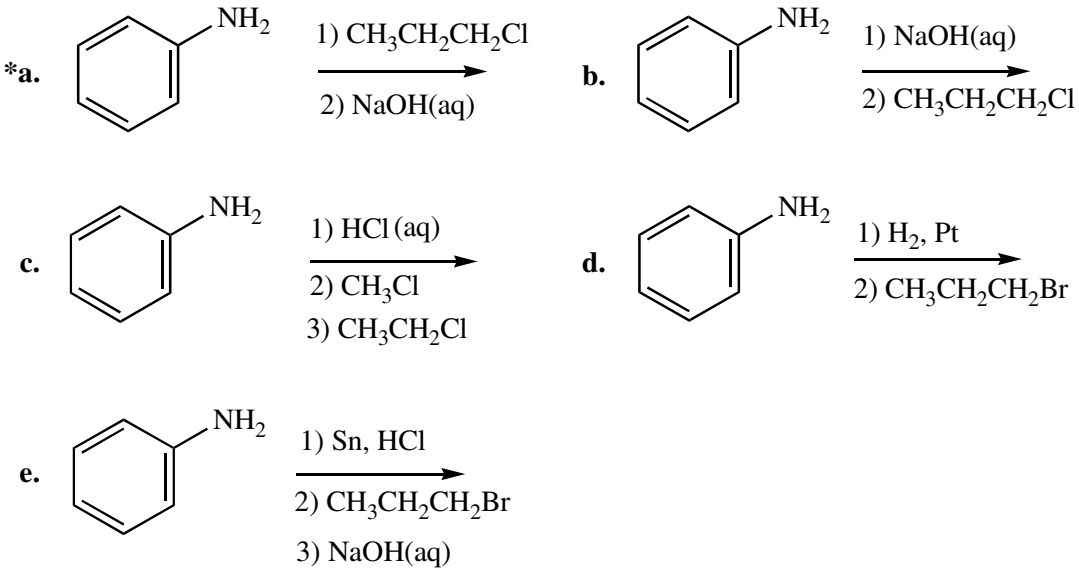


IV

a. I ***b.** II **c.** III
d. IV **e.** none of the above

Reactions

11.20. $C_6H_5NHCH_2CH_2CH_3$ can best be prepared as follows:



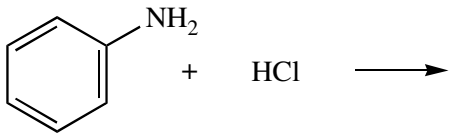
11.21. Reacting aniline, $C_6H_5NH_2$, with a primary alkyl halide will produce a(n):

a. 1° amine ***b.** 2° amine **c.** 3° amine **d.** amide **e.** imine

11.22. An imine is produced when a ketone or aldehyde reacts with:

a. methyl alcohol **b.** Zn(Hg), HCl ***c.** an amine
d. an amide **e.** HCN

11.23. What is the name of the product of the following reaction?

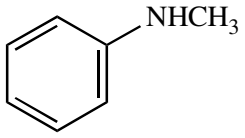


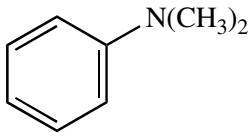
a. chlorobenzene **b.** chloroaniline ***c.** anilinium chloride
d. o-chloroaniline **e.** N-chloroaniline

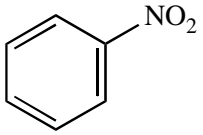
11.24. What is the stereochemical relationship of the *products* formed by reacting racemic lactic acid with (*S*)-1-phenylethylamine?

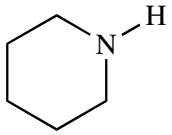
a. enantiomers **b.** meso compounds **c.** racemic mixture
***d.** diastereomers **e.** geometric isomers

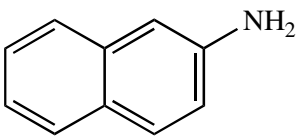
11.25. Which of the following amines can be converted to an aryl diazonium salt?

a. 

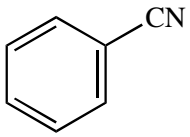
b. 

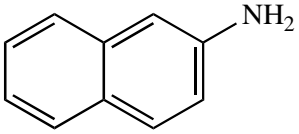
c. 

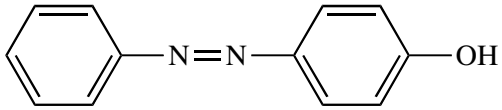
d. 

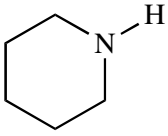
***e.** 

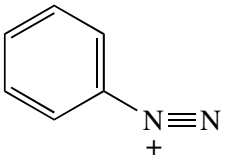
11.26. Which molecule is known as an azo compound?

a. 

b. 

***c.** 

d. 

e. 

11.27. What is the name of the product formed by reacting CuBr and HBr with benzenediazonium chloride?

***a.** bromobenzene **b.** chlorobenzene **c.** *o*-bromoaniline
d. *m*-bromoaniline **e.** *m*-chloroaniline

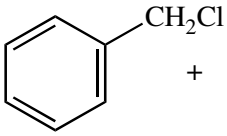
11.28. What reacts with benzenediazonium chloride to produce benzonitrile?

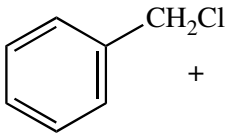
a. HONO **b.** Li, NH_3 **c.** $NaBH_3CN$
***d.** KCN, Cu_2CN_2 **e.** $LiAlH_4$, ether

11.29. What type of products are formed by diazo coupling reactions?

a. meso compounds ***b.** azo compounds
c. diazonium salts **d.** quaternary ammonium salts
e. racemic mixtures

11.30. Which reaction will produce a quaternary ammonium salt?

a.  + CH_3NH_2 ⟶ **?**

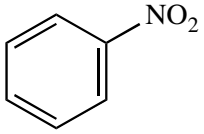
b.  + $(CH_3)_2NH$ ⟶ **?**

c. $(CH_3)_3CBr$ + CH_3NH_2 ⟶ **?**

***d.** CH_3CH_2I + $(CH_3)_3N$ ⟶ **?**

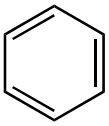
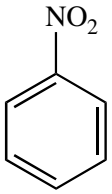
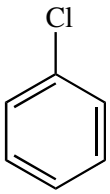
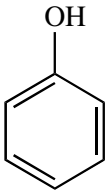
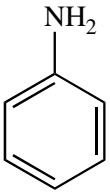
e. $(CH_3)_2CHBr$ + $(CH_3)_2NH$ ⟶ **?**

11.31. What is the final product for the following sequence of reactions?

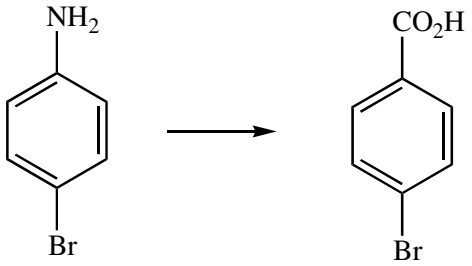


1) $SnCl_2$, HCl
2) $NaNO_2$, HCl
3) H_3PO_2

⟶ **?**

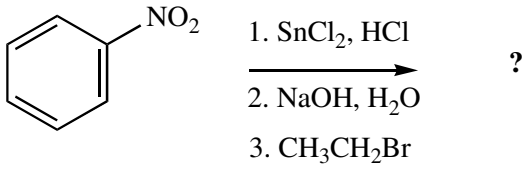
***a.**  **b.**  **c.**  **d.**  **e.** 

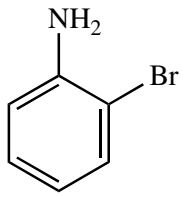
11.32. Which of the following reaction sequences will convert *p*-bromoaniline to *p*-bromobenzoic acid?

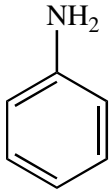


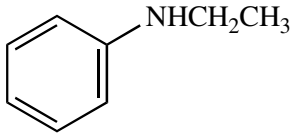
a. 1. $NaNO_2$, HCl 2. CH_3CO_2H
b. 1. $NaNO_2$, HCl 2. Mg, ether 3. CO_2, H_3O^+
c. 1. CH_3Cl, $AlCl_3$ 2. $KMnO_4$
d. 1. HCl 2. CH_3COCl 3. NaCN, H_3O^+
***e.** 1. $NaNO_2$, HCl 2. KCN, Cu_2CN_2 3. H_3O^+

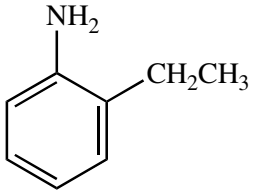
11.33. The following reaction sequence will produce:

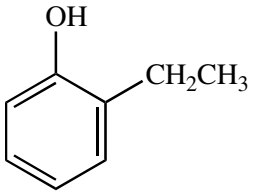


a. 

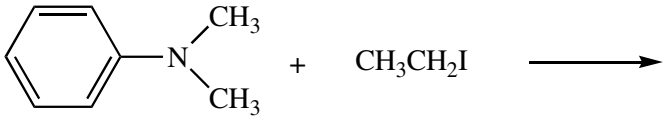
b. 

***c.** 

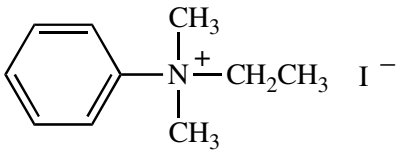
d. 

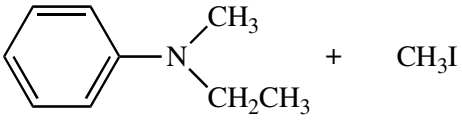
e. 

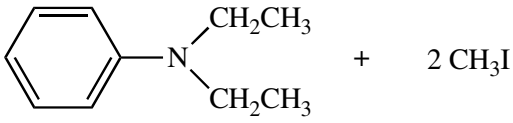
11.34. The product(s) of

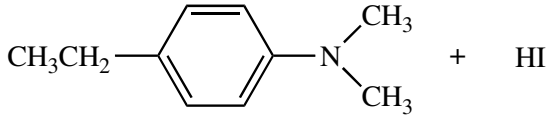


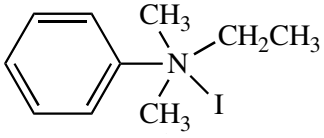
are:

***a.** 

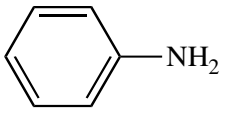
b. 

c. 

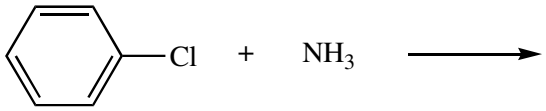
d. 

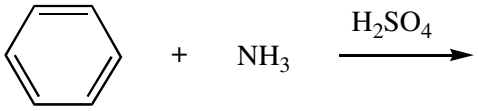
e. 

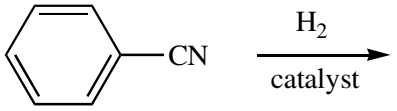
11.35. Aniline

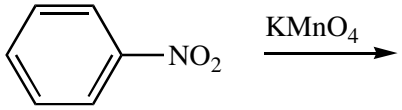


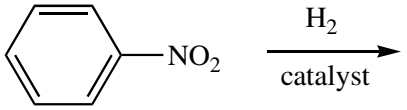
is best prepared via:

a. 

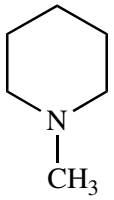
b. 

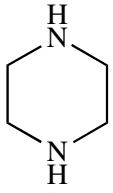
c. 

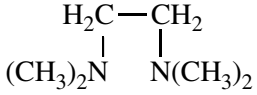
d. 

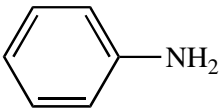
***e.** 

11.36. The amines that can be acylated by acetic anhydride are

1. 

2. 

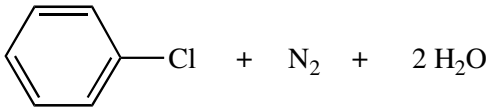
3. 

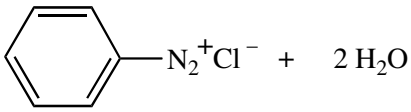
4. 

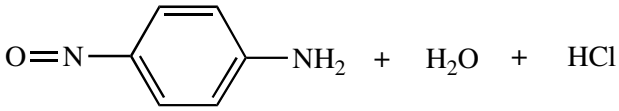
a. only 4 **b.** 1, 2, 3, and 4 **c.** 1 and 3
***d.** 2 and 4 **e.** only 2

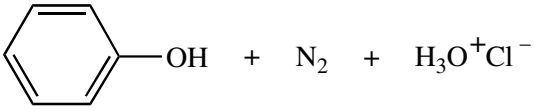
11.37. The product(s) from the reaction

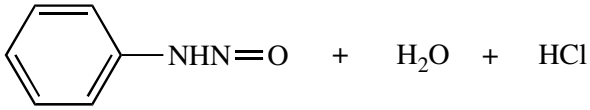
are:

a. 

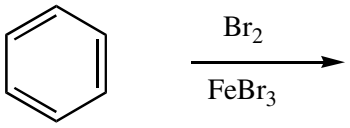
***b.** 

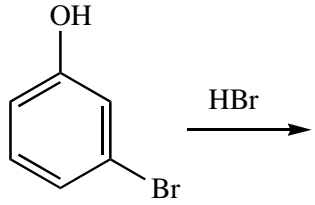
c. 

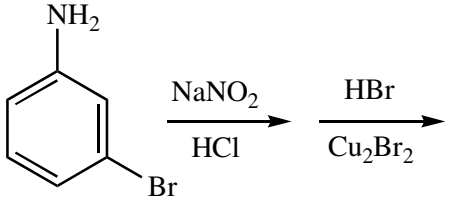
d. 

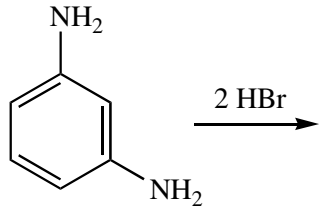
e. 

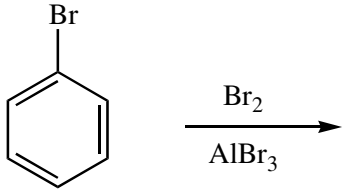
11.38. *m*-Dibromobenzene can be prepared in good yield by the sequence

a. 

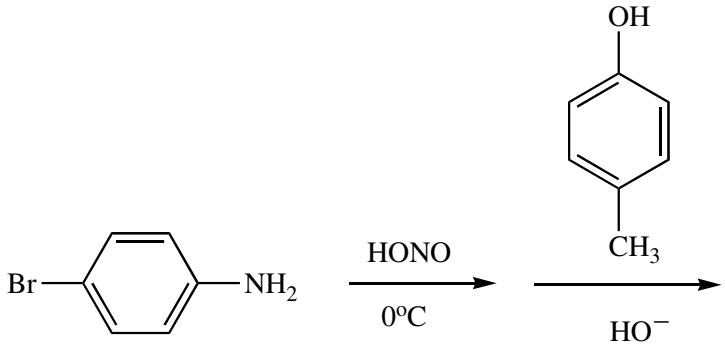
b. 

***c.** 

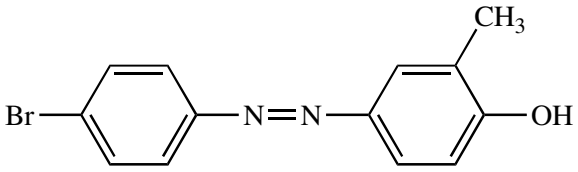
d. 

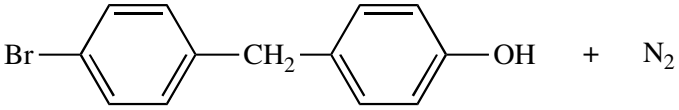
e. 

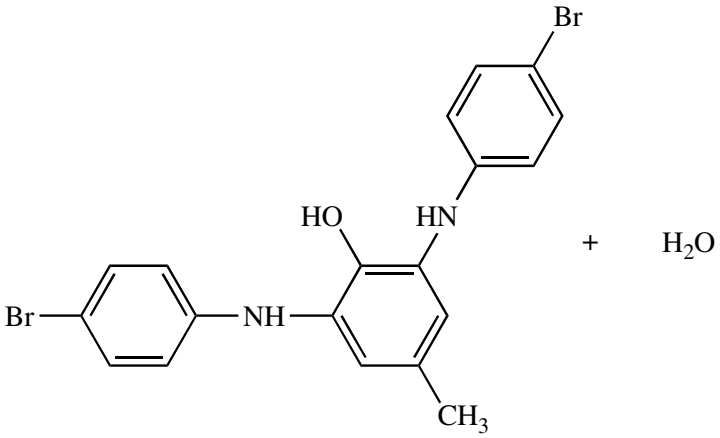
11.39. The product(s) from the reaction sequence

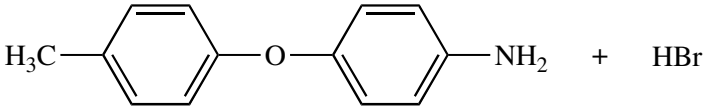


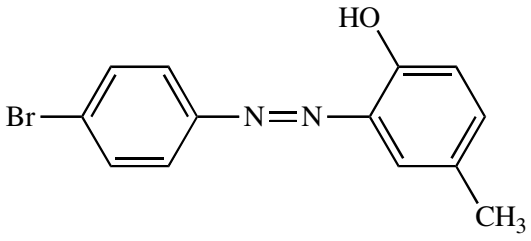
is (are):

a. 

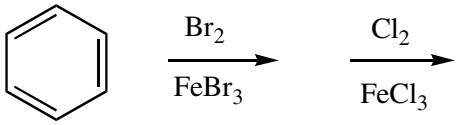
b. 

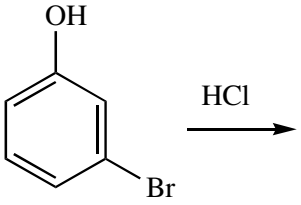
c. 

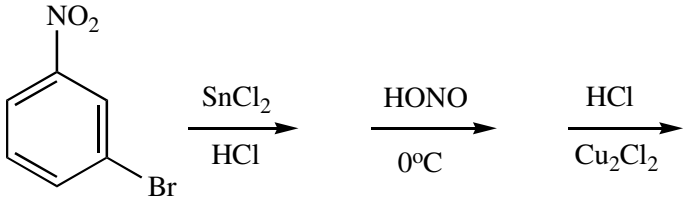
d. 

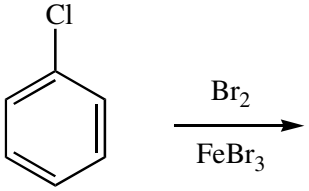
***e.** 

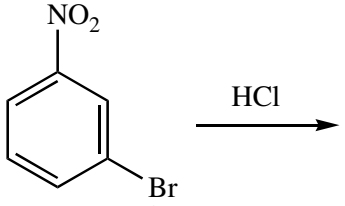
11.40. *m*-Chlorobromobenzene can be prepared in good yield by the sequence:

a. 

b. 

***c.** 

d. 

e. 

11.41. The reaction of a 2° amine with nitrous acid gives:

a. a quaternary ammonium salt.
***b.** a nitrosamine.
c. A diazonium salt
d. an azo dye
e. a nitro compound