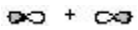
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Organic Chemistry, 9e **(Wade)**
Chapter 2 Acids and Bases; Functional Groups

1) An orbital can be described by its _____, which is the mathematical description of the shape of the electron wave as it oscillates.
Answer: wave function
Diff: 1
Section: 1.12
LO: 2.1

2) The electron density at any point is proportional to the _____ of the electron wave at that point.
Answer: square of the wave function
Diff: 2
Section: 1.12
LO: 2.1

3) Which atomic orbital combination would result in a molecular sigma bond?
A) 
B) 
C) 
D) 
Answer: B
Diff: 1
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.7

4) Two p orbitals can overlap to form a σ molecular orbital. How many nodes are present in this σ molecular orbital?
A) 0
B) 1
C) 2
D) 3
Answer: C
Diff: 1
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.7

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5) Two p orbitals can overlap to form a σ* molecular orbital. How many nodes are present in this σ* molecular orbital?
A) 0
B) 1
C) 2
D) 3
Answer: D
Diff: 1
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.7

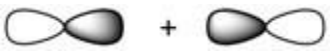
6) When orbitals on different atoms interact, _____ are produced.
Answer: molecular orbitals
Diff: 1
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.1

7) What kind of molecular orbital (σ, σ^*, π, or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: σ^*
Diff: 2
Section: 1.13
LO: 2.1
GO: G2
MCAT LO: MCAT2.7

8) What kind of molecular orbital (σ, σ^*, π, or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: σ
Diff: 2
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.7

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9) What kind of molecular orbital (σ, σ*, π, or π*) results when the two atomic orbitals shown below interact in the manner indicated?



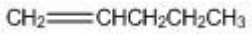
Answer: σ*
Diff: 2
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.7

10) How many carbon-carbon σ bonds are present in the molecule shown?



A) 1
B) 2
C) 3
D) 4
E) 5
Answer: E
Diff: 2
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.1

11) How many carbon-carbon σ bonds are present in the molecule shown?

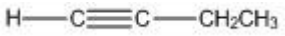


A) 1
B) 2
C) 3
D) 4
E) 5
Answer: D
Diff: 2
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.1

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12) How many carbon-carbon σ bonds are present in the molecule shown?

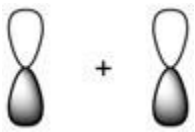


A) 1
B) 2
C) 3
D) 4
E) 5
Answer: C
Diff: 2
Section: 1.13
LO: 2.1
GO: G2
MCAT LO: MCAT2.1

13) Consider the interaction of two hydrogen 1s atomic orbitals of the same phase. Which of the statements below is an incorrect description of this interaction?
A) A sigma bonding molecular orbital is formed.
B) The molecular orbital formed is lower in energy than a hydrogen 1s atomic orbital.
C) The molecular orbital formed has a node between the atoms.
D) The molecular orbital formed is cylindrically symmetric.
E) A maximum of two electrons may occupy the molecular orbital formed.
Answer: C
Diff: 3
Section: 1.13
LO: 2.1
MCAT LO: MCAT2.7

14) A _____ bond results when parallel p orbitals overlap sideways.
Answer: π
Diff: 1
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.7

15) What kind of molecular orbital (σ, σ^*, π, or π^*) results when the two atomic orbitals shown below interact in the manner indicated?

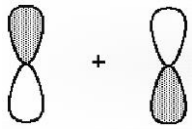


Answer: π
Diff: 2
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.7

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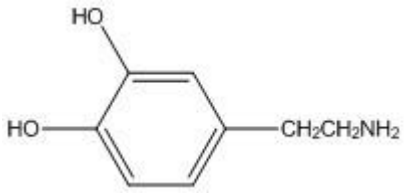
16) What kind of molecular orbital (σ, σ*, π, or π*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: π*
Diff: 2
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.7

17) If a compound, C_5H_7NO, contains 1 ring, how many pi bonds are there in this compound?
A) 0
B) 1
C) 2
D) 3
Answer: C
Diff: 2
Section: 1.14
LO: 2.1
GO: G2
MCAT LO: MCAT2.1

18) How many π bonds are present in the molecule shown?



A) 0
B) 1
C) 3
D) 4
E) 6
Answer: C
Diff: 2
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.1

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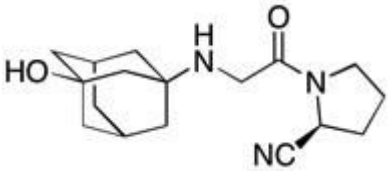
19) How many π bonds are present in the molecule shown?



A) 0
B) 1
C) 2
D) 4
E) 6
Answer: C
Diff: 2
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.1

20) Which of the following statements about π molecular orbitals is/are correct?
A) π molecular orbitals are cylindrically symmetric.
B) Most of the electron density in a π molecular orbital is centered above and below the internuclear axis.
C) When two atoms are connected by a double bond, both of these bonds are π bonds.
D) Both statements B and C are correct.
E) Statements A, B, and C are all correct.
Answer: B
Diff: 3
Section: 1.14
LO: 2.1
MCAT LO: MCAT2.7

21) Vildagliptin is a recently released antidiabetic drug (*J. Med. Chem.* **2010**, 7902). How many elements of unsaturation are in Vildagliptin?



A) 4
B) 5
C) 6
D) 7
Answer: D
Diff: 3
Section: 7.3
LO: 7.1
GO: G2, G5

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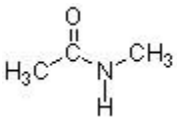
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22) What is the approximate value of any HCC bond angle in $H_2C{=}CHCCl_3$?
Answer: 120°
Diff: 1
Section: 1.15
LO: 2.2
MCAT LO: MCAT2.7

23) What is the approximate value of the CCC bond angle in $CH_3CH_2CH_2OH$?
Answer: 109.5°
Diff: 1
Section: 1.15
LO: 2.2
MCAT LO: MCAT2.7

24) What is the approximate value of the CCC bond angle in $CH_3C{\equiv}CCH_3$?
Answer: 180°
Diff: 1
Section: 1.15
LO: 2.2
MCAT LO: MCAT2.7

25) Based on the structure below, what is the value for the H-N-CH_3 bond angle?

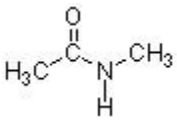


A) 60 degrees
B) 90 degrees
C) 109 degrees
D) 120 degrees
Answer: D
Diff: 2
Section: 1.15
LO: 2.2
GO: G2
MCAT LO: MCAT2.2

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26) In the structure below, the sigma bond of the carbonyl is formed from the overlap of a(n) _____ atomic orbital of carbon and a(n) _____ atomic orbital of oxygen.



A) *sp*, *sp*^{2}
B) *sp*^{3}, *sp*^{2}
C) *sp*^{2}, *sp*^{2}
D) p, p
Answer: C
Diff: 2
Section: 1.15
LO: 2.2
GO: G2
MCAT LO: MCAT2.7

27) Choose the term below which best describes the geometry of acetylene (HCCH).
A) trigonal bipyramidal
B) trigonal
C) tetrahedral
D) square planar
E) linear
Answer: E
Diff: 2
Section: 1.15
LO: 2.2
MCAT LO: MCAT2.2

28) In the structure below, the hybridization of the oxygen is _____ and the C-O-C bond angle is _____.

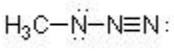


A) *sp*^{2}; 120°
B) *sp*^{2}; <109.5°
C) *sp*^{3}; 120°
D) *sp*^{3}; <109.5°
E) *sp*; 120°
Answer: D
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

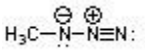
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29) Complete the structure of methyl azide by adding any necessary formal charges.

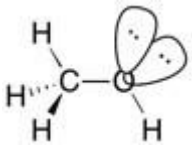


Answer:



Diff: 2
Section: 1.7
LO: 1.3
GO: G2
MCAT LO: MCAT1.2

30) Draw a three-dimensional model of methanol, CH_3OH, including lone pairs of electrons using wedges, dashes and straight lines.
Answer:



Diff: 2
Section: 1.16
LO: 2.2
MCAT LO: MCAT2.2

31) The HCH bond angle in allene (H_2CCCH_2) is _____.
Answer: approximately 120°
Diff: 2
Section: 2.4
LO: 2.2
GO: G2
MCAT LO: MCAT2.2

32) What two hybrid atomic orbitals overlap to form the C-C σ bond in acetonitrile, $CH_3C{\equiv}N$?
Answer: Csp^3 and Csp
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

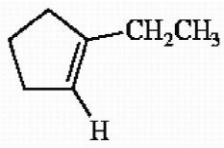
33) What two hybrid atomic orbitals overlap to form the C-C σ bond in acetaldehyde, CH_3CHO?
Answer: Csp^3 and Csp^2
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

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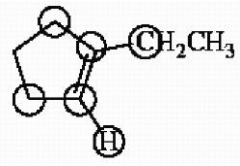
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34) What two hybrid atomic orbitals overlap to form the C-C σ bond in allene, $H_2C=C=CH_2$?
Answer: C*sp* and Csp^2
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

35) Circle the coplanar atoms in 1-ethylcyclopentene shown below.

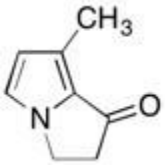


Answer:



Diff: 2
Section: 1.17
LO: 2.2
GO: G2
MCAT LO: MCAT2.2

36) Shown below is one of the sex pheremones from the butterfly family. How many sp^3 hybridized carbon atoms are present?

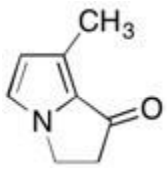


A) 1
B) 2
C) 3
D) 4
E) 5
Answer: C
Diff: 2
Section: 1.17
LO: 2.2
GO: G2, G5
MCAT LO: MCAT2.2

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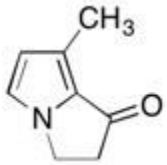
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37) Shown below is one of the sex pheremones from the butterfly family. How many sp^2 hybridized carbon atoms are present in this molecule?



A) 1
B) 2
C) 3
D) 4
E) 5
Answer: E
Diff: 2
Section: 1.17
LO: 2.2
GO: G2, G5
MCAT LO: MCAT2.2

38) Shown below is one of the sex pheremones from the butterfly family. How many *sp* hybridized carbon atoms are present in this molecule?



A) 0
B) 1
C) 2
D) 3
E) 5
Answer: A
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

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39) Choose the correct hybridization for the atom indicated in the molecule below.

$CH_3CH_2CH_2CH_3$
↑

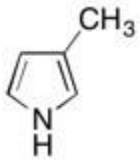
A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: C
Diff: 1
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

40) Choose the correct hybridization for the atom indicated in the molecule below.

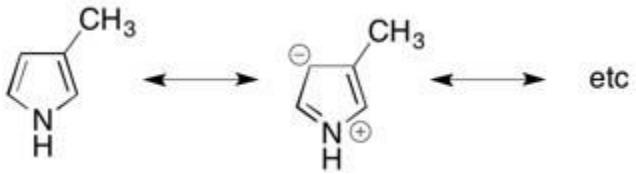
$CH_3CH_2CH_2CH_3$
↑

A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: C
Diff: 1
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

41) The hybridization of the nitrogen in the molecule shown below is sp^2. Briefly explain why.



Answer: This molecule has resonance structures where the lone pair on the nitrogen is delocalized in to the ring through a pi bond. This requires the nitrogen to be sp^2 hybridized.

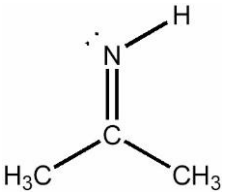


Diff: 1
Section: 1.17
LO: 2.1
GO: G2

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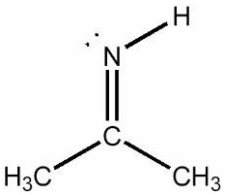
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42) What is the hybridization of the nitrogen atom in the molecule below?



A) s
B) *sp*
C) sp^2
D) sp^3
E) none of the above
Answer: C
Diff: 1
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

43) What is the approximate CCC bond angle in the compound below?

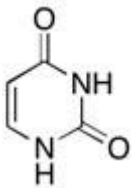


A) 60°
B) 90°
C) 109.5°
D) 120°
E) 180°
Answer: D
Diff: 1
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

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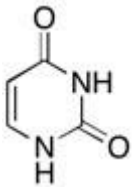
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44) The structure of uracil is shown below. What is the hybridization of the nitrogens?



Answer: Both are sp^2, (resonance structures with pi bonds)
Diff: 1
Section: 1.17
LO: 2.2
GO: G7
MCAT LO: MCAT2.2

45) The structure of uracil is shown below. What is the molecular shape of the nitrogens?



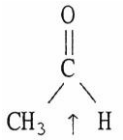
Answer: Both are trigonal planar (resonance structures exist with pi bonds to the nitrogen)
Diff: 1
Section: 1.17
LO: 2.2
GO: G7
MCAT LO: MCAT2.2

46) Triethylamine [$(CH_3CH_2)_3N$] is a molecule in which the nitrogen atom is _____ hybridized and the CNC bond angle is _____.
A) sp^2; >109.5°
B) sp^2; <109.5°
C) sp^3; >109.5°
D) sp^3; <109.5°
E) *sp*; 109.5°
Answer: D
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

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47) Choose the correct hybridization for the atom indicated in the molecule below.



A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: B
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

48) Choose the correct hybridization for the atom indicated in the molecule below.

$(CH_3)_2CHCN$
↑

A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: A
Diff: 2
Section: 1.17
LO: 2.2
GO: G2
MCAT LO: MCAT2.2

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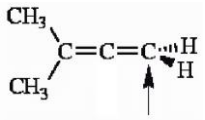
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49) Choose the correct hybridization for the atom indicated in the molecule below.

$(CH_3)_2CHCN$
↑

A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: C
Diff: 2
Section: 1.17
LO: 2.2
GO: G2
MCAT LO: MCAT2.2

50) Choose the correct hybridization for the atom indicated in the molecule below.

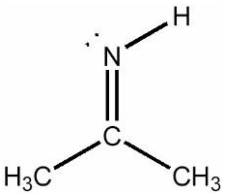


A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: B
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

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51) How many σ bonds does the compound shown contain?



A) 3
B) 5
C) 9
D) 10
E) 11
Answer: D
Diff: 2
Section: 1.17
LO: 2.1
MCAT LO: MCAT2.7

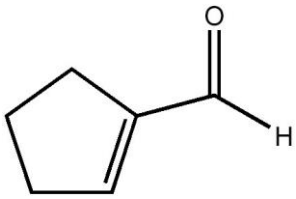
52) Acrylonitrile (CH_2=CHCN) contains _____ σ bonds and _____ π bonds.
A) 4; 1
B) 6; 3
C) 4; 3
D) 6; 1
E) 2; 0
Answer: B
Diff: 2
Section: 1.17
LO: 2.1
MCAT LO: MCAT2.7

53) The CCN bond angle in acrylonitrile (CH_2=CHCN) is approximately _____.
A) 60°
B) 90°
C) 109.5°
D) 120°
E) 180°
Answer: E
Diff: 2
Section: 1.17
LO: 2.2
GO: G2
MCAT LO: MCAT2.2

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54) Which of the following statements concerning the cyclic molecule shown is not true?



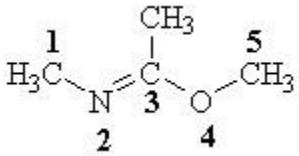
A) It contains a π molecular orbital formed by the overlap of a carbon p atomic orbital with an oxygen p atomic orbital.
B) It contains a σ molecular orbital formed by the overlap of two carbon sp^2 hybrid atomic orbitals.
C) It contains a σ molecular orbital formed by the overlap of two carbon sp^3 hybrid atomic orbitals.
D) It contains a π molecular orbital formed by the overlap of two carbon p atomic orbitals.
E) It contains a σ molecular orbital formed by the overlap of a carbon p atomic orbital with an oxygen sp^3 atomic orbital.
Answer: E
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

55) The HNC bond angle in the cation $[CH_2NH_2]^+$ is approximately _____.
A) 60°
B) 90°
C) 109.5°
D) 120°
E) 180°
Answer: D
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

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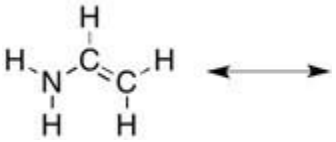
56) Which of the labeled atoms in the following structure are *sp*^{2} hybridized?



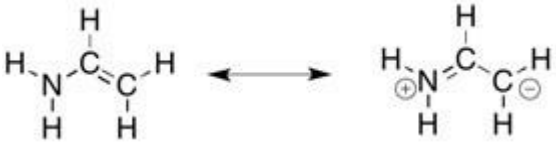
A) 1 & 4
B) 2 & 5
C) 2 & 4
D) 2 & 3
E) 2, 3, & 4
Answer: D
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

57) The HCN bond angle in hydrogen cyanide (HCN) is _____.
Answer: 180°
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

58) There is one more important resonance form for the structure below. Draw it and then indicate the hybridization of all of the non-H atoms.



Answer:



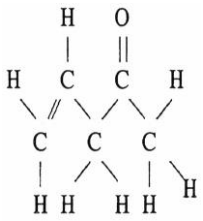
All non-H atoms are sp^2 hybridized.
Diff: 2
Section: 1.17
LO: 2.3
GO: G7
MCAT LO: MCAT2.3

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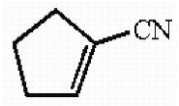
59) The CCO bond angle in acetone (CH_3COCH_3) is _____.
Answer: approximately 120°
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

60) The molecule shown below contains _____ pi bonds and _____ sigma bonds.



Answer: 2, 13
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

61) The molecule shown below contains _____ sigma bonds and _____ pi bonds.



Answer: 14 sigma, 3 pi
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

62) What hybrid atomic orbitals are overlapping to form the carbon-oxygen σ bond in acetaldehyde (CH_3CHO)?
Answer: carbon sp^2 and oxygen sp^2
Diff: 2
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

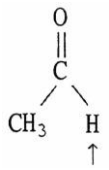
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63) Provide the hybridization of oxygen in dimethyl ether (CH_3OCH_3) and estimate the COC bond angle.
Answer: The hybridization of the oxygen atom is sp^3 and the COC bond angle is slightly less than 109.5°.
Diff: 2
Section: 1.17
LO: 2.2
GO: G7
MCAT LO: MCAT2.7

64) Provide the hybridization of oxygen in acetaldehyde (CH_3CHO) and estimate the OCH bond angle.
Answer: The hybridization of the oxygen atom is sp^2 and the OCH bond angle is approximately 120°.
Diff: 2
Section: 1.17
LO: 2.2
GO: G7
MCAT LO: MCAT2.7

65) Choose the correct hybridization for the atom indicated in the molecule below.

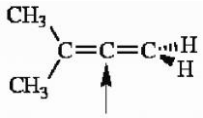


A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: D
Diff: 3
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.7

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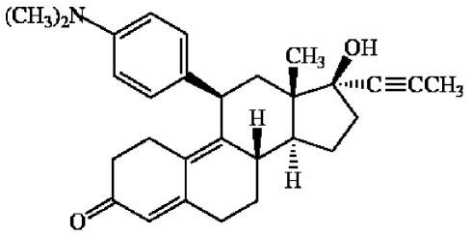
66) Choose the correct hybridization for the atom indicated in the molecule below.



A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: A
Diff: 3
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

67) Boron trifluoride (BF_3) is a molecule in which the boron atom is _____ hybridized and the FBF bond angle is _____.
Answer: sp^2, 120°
Diff: 3
Section: 1.17
LO: 2.2
MCAT LO: MCAT2.2

68) The synthetic steroid RU-486 is shown below. How many pi bonds does RU-486 contain?



Answer: 8
Diff: 3
Section: 1.17
LO: 2.1
GO: G5
MCAT LO: MCAT2.7

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69) Structures which differ only in rotations about a single bond are called _____.
Answer: Conformations
Diff: 2
Section: 1.18
LO: 2.1
MCAT LO: MCAT2.9

70) From a molecular orbital perspective, why is there relatively free rotation about the carbon-carbon bond of ethane (CH_3CH_3)?
Answer: This carbon-carbon σ bond is formed by the cylindrically symmetric overlap of two sp^3 hybrid orbitals. Rotation about this bond does not disrupt the orbital overlap.
Diff: 2
Section: 1.18
LO: 2.1
GO: G2
MCAT LO: MCAT2.9

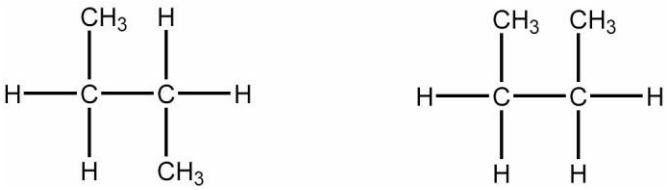
71) From a molecular orbital perspective why isn't there relatively free rotation about the carbon-carbon double bond in ethene ($CH_2=CH_2$)?
Answer: Two carbon p atomic orbitals overlap side-to-side and in phase to form the π bond that is present. Rotation about the carbon-carbon bond axis requires quite a bit of energy because the π bond is broken as the overlap between the two p orbitals is disrupted.
Diff: 2
Section: 1.18
LO: 2.4
GO: G2
MCAT LO: MCAT2.9

72) Explain why the free rotation about the carbon-carbon bond in CH_3CH_3 is not present in CH_2CH_2.
Answer: The single carbon-carbon sigma bond present in CH_3CH_3 is formed by the overlap of two C sp^3 hybrid atomic orbitals. The overlap of these orbitals is not disrupted by rotation about the carbon-carbon bond axis. In the case of CH_2CH_2, the carbon-carbon bond is a double bond with both a sigma and pi bond present. Rotation about the carbon-carbon bond axis disrupts the overlap of the two carbon p orbitals forming the pi bond.
Diff: 2
Section: 1.18
LO: 2.4
GO: G2
MCAT LO: MCAT2.9

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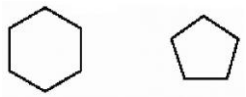
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73) Which of the following best describes the relationship between the two structures shown?



A) They represent the same compound.
B) They represent different compounds that are constitutional isomers.
C) They represent different compounds that are geometric isomers.
D) They represent different compounds that are alkenes.
E) They represent different compounds that are alkanes.
Answer: A
Diff: 1
Section: 1.19
LO: 2.4
GO: G2
MCAT LO: MCAT2.4

74) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?



Answer: not isomeric
Diff: 1
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

75) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?

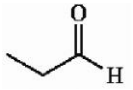


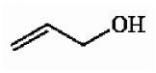
Answer: constitutional isomers
Diff: 1
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

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76) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?





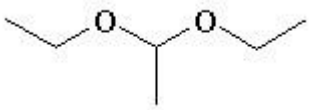
Answer: constitutional isomers
Diff: 2
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

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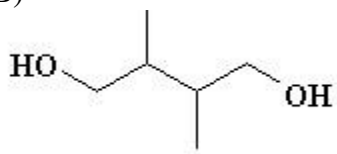
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77) Which of the following compounds is <u>not</u> a constitutional isomer of a compound with an empirical formula C_3H_7O and a formula mass of 118.164?

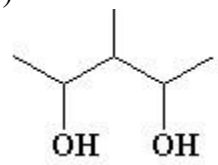
A)



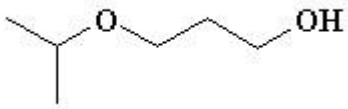
B)



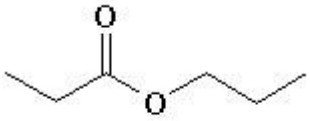
C)



D)



E)

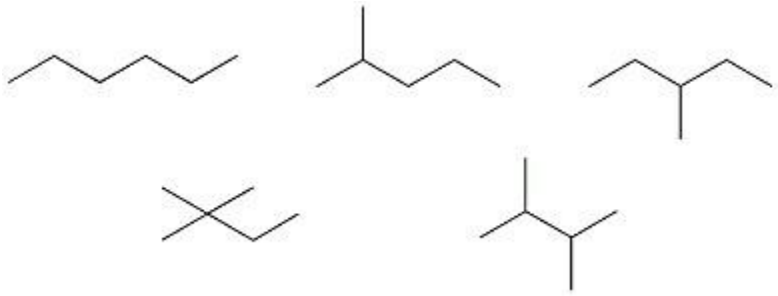


Answer: E
Diff: 2
Section: 1.19
LO: 2.4
GO: G7
MCAT LO: MCAT2.4

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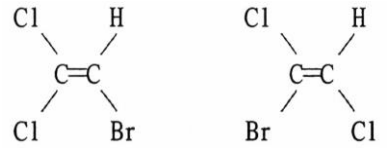
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78) Provide the skeletal structures of the five constitutional isomers with molecular formula C_6H_{14}.
Answer:



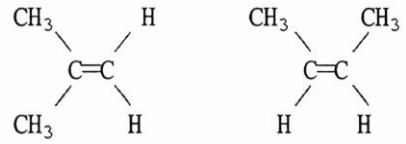
Diff: 2
Section: 1.19
LO: 1.2
GO: G2
MCAT LO: MCAT1.1

79) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?



Answer: constitutional isomers
Diff: 2
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

80) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?

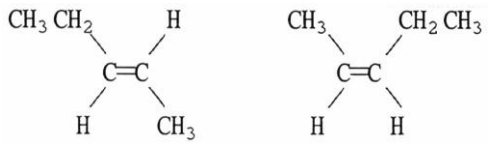


Answer: constitutional isomers
Diff: 2
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

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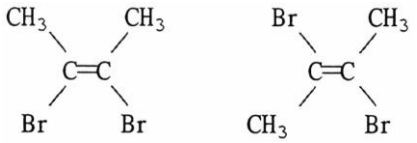
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81) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?



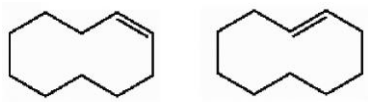
Answer: cis-trans isomers
Diff: 2
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

82) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?



Answer: cis-trans isomers
Diff: 2
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

83) Are the two compounds shown below best described as cis-trans isomers, constitutional isomers, or not isomeric?



Answer: cis-trans isomers
Diff: 2
Section: 1.19
LO: 2.4
MCAT LO: MCAT2.4

84) Provide the condensed formulas of three structural isomers with molecular formula C_5H_{12} and arrange them in order of increasing boiling point.
Answer: $C(CH_3)_4 < (CH_3)_2CHCH_2CH_3 < CH_3(CH_2)_3CH_3$
Diff: 2
Section: 2.2
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

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85) A molecule of acetylene (C_2H_2) has a _____ geometry and a molecular dipole moment that is _____.
A) tetrahedral; nonzero
B) bent; nonzero
C) bent; zero
D) linear; nonzero
E) linear; zero
Answer: E
Diff: 1
Section: 2.1
LO: 2.2
MCAT LO: MCAT2.6

86) Which of the following statements is correct?
A) Higher molecular dipole values (μ) are associated with nonpolar molecules
B) All polar molecules are capable of hydrogen bond formation
C) The polarity of a molecule is dependent on its three-dimensional structure
D) Induced dipole interactions are usually stronger than dipole-dipole interactions
E) Polar solutes tend to be more soluble in nonpolar solvents
Answer: C
Diff: 1
Section: 2.1
LO: 2.2
MCAT LO: MCAT2.6

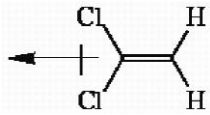
87) Which one of the molecules shown below has no net molecular dipole moment?
A) CH_3Cl
B) $H_2C{=}CH_2$
C) CH_2O
D) CH_2Cl_2
E) CH_3OH
Answer: B
Diff: 2
Section: 2.1
LO: 2.5
GO: G2
MCAT LO: MCAT2.6

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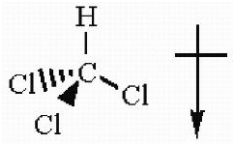
88) Which one of the molecules shown below has a net molecular dipole moment?
A) CCl_4
B) CO_2
C) CH_3CCl_3
D) $BeCl_2$
Answer: C
Diff: 2
Section: 2.1
LO: 2.5
GO: G2
MCAT LO: MCAT2.6

89) Does 1,1-dichloroethene ($Cl_2C{=}CH_2$) have a net molecular dipole moment? If it does, draw the molecule and indicate the direction of this molecular dipole moment.
Answer: Net molecular dipole moment present.



Diff: 2
Section: 2.1
LO: 2.5
GO: G2
MCAT LO: MCAT2.6

90) Draw the three-dimensional structure of chloroform ($CHCl_3$) and show the direction of the molecular dipole moment.
Answer:

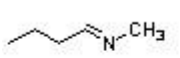


Diff: 2
Section: 2.1
LO: 2.5
GO: G7
MCAT LO: MCAT2.6

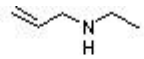
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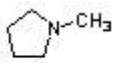
91) Which sequence ranks the following isomers in order of increasing boiling points?



1



2

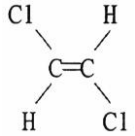


3

A) 2<1<3
B) 2<3<1
C) 3<1<2
D) 3<2<1
Answer: C
Diff: 2
Section: 2.2
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

92) Does the C—O bond in methanol (CH_3OH) possess an individual bond dipole moment? Briefly explain your answer.
Answer: Yes, the C—O bond in methanol does have an individual bond dipole moment since the C and O atoms comprising the bond have differing electronegativities.
Diff: 3
Section: 19.9
LO: 2.5
MCAT LO: MCAT1.5

93) Draw the structure of the isomeric form of 1,2-dichloroethene (CHCl═CHCl) which has no net dipole moment.
Answer:



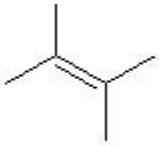
Diff: 3
Section: 19.9
LO: 2.5
GO: G2
MCAT LO: MCAT2.6

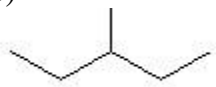
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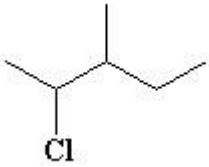
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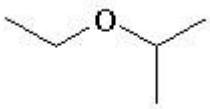
94) Which of the following has the highest boiling point?

A)


B)


C)


D)


E)


Answer: A
Diff: 1
Section: 2.2
LO: 2.5
MCAT LO: MCAT2.5

95) What intermolecular forces are present among molecules in dimethyl ether, CH_3OCH_3?
A) London forces only
B) hydrogen bonding only
C) both London dispersion forces and hydrogen bonding
D) both London dispersion forces and dipole-dipole forces
Answer: D
Diff: 2
Section: 2.2
LO: 2.3
GO: G2

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96) Which of the molecules below can hydrogen bond to another of the same compound?
A) $CH_3CH_2OCH_2CH_3$
B) $CH_3CH_2COOCH_3$
C) $(CH_3CH_2)_2CHOH$
D) $CH_3CH_2COCH_2CH_3$
E) all of the above
Answer: C
Diff: 2
Section: 2.2
LO: 2.3
GO: G2

97) What intermolecular attractions exist in a pure sample of methylthiol, CH_3SH?
Answer: London dispersion forces and dipole-dipole attractions.
Diff: 2
Section: 2.2
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

98) Which of the molecules below has the higher boiling point? Briefly explain your choice.

$CH_3CH_2CH_2OH$ or $CH_3CH_2OCH_3$
Answer: $CH_3CH_2CH_2OH$ has the higher boiling point since it is capable of intermolecular hydrogen bonding.
Diff: 2
Section: 2.2
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

99) Which of the molecules below has the higher boiling point? Briefly explain your choice.

$CH_3CH_2CH_2CH_2CH_3$ or $(CH_3)_2CHCH_2CH_3$
Answer: $CH_3CH_2CH_2CH_2CH_3$ has the higher boiling point. As the degree of branching increases, the surface area of the molecule decreases and the potential for intermolecular attraction via London forces decreases. Greater surface area leads to a more intermolecular attraction which in results in a higher boiling point.
Diff: 2
Section: 2.2
LO: 2.5
GO: G2, G8
MCAT LO: MCAT2.5

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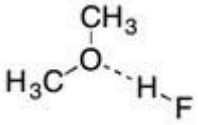
100) Would you expect sodium chloride (NaCl) to be highly soluble in the organic solvent hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)? Briefly explain your answer.

Answer: One would <u>not</u> expect NaCl to be highly soluble in hexane. NaCl is an ionic solid (i.e., a very polar material) while hexane is nonpolar. Nonpolar solvent molecules do not solvate ions well. The attractions of oppositely charged ions to each other are vastly greater than the weak attractions of the ions for the solvent.

Diff: 2
Section: 2.3
LO: 2.5
GO: G2, G8
MCAT LO: MCAT2.5

101) Draw the hydrogen bonding that takes place between H-F and dimethyl ether CH_3OCH_3.

Answer:



Diff: 2
Section: 2.2
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

102) Which of the molecules below has the higher boiling point? Briefly explain your choice.

$(CH_3)_3N$ or $CH_3CH_2CH_2NH_2$

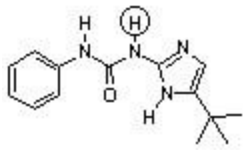
Answer: $CH_3CH_2CH_2NH_2$ has the higher boiling point since it is capable of intermolecular hydrogen bonding.

Diff: 3
Section: 2.2
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

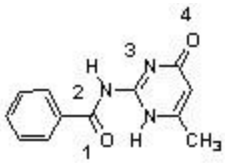
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103) The compounds below are base pairs used to form supramolecular polymers (*Org. Lett.* **2011**, 240). They are held together by three intermolecular hydrogen bonds and each contains one intramolecular hydrogen bond. Which atom in structure B forms a hydrogen bond with the circled hydrogen in structure A?



Structure A



Structure B

A) 1
B) 2
C) 3
D) 4
Answer: C
Diff: 3
Section: 2.2
LO: 2.5
GO: G2, G5
MCAT LO: MCAT2.5

104) Which compound is more soluble in water? Briefly explain your choice.

$(CH_3)_2NH$ or $CH_3CH_2CH_3$
Answer: $(CH_3)_2NH$ is more soluble in water since it can hydrogen bond with water. Alkanes are not capable of hydrogen bonding with water.
Diff: 2
Section: 2.3
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

105) Which compound is more soluble in water? Briefly explain your choice.

CH_3OCH_3 or CH_3CH_2OH
Answer: CH_3CH_2OH is more soluble in water since it can donate a hydrogen bond to water and accept a hydrogen bond from water. CH_3OCH_3 can only accept a hydrogen bond from water; it does not have hydrogen which can hydrogen bond to water.
Diff: 3
Section: 2.3
LO: 2.5
GO: G2
MCAT LO: MCAT2.5

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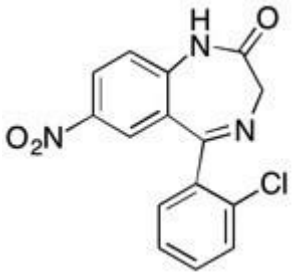
106) Which functional groups below indicate the presence of two atoms connected by a triple bond?
A) alkyne
B) alkene
C) nitrile
D) ester
E) both A and C
Answer: E
Diff: 2
Section: 2.15
LO: 2.6
GO: G2

107) What name is given to a hydrocarbon that contains a six-membered ring of alternating single and double bonds?
A) alkane
B) alkene
C) alkyne
D) aromatic
E) none of the above
Answer: D
Diff: 1
Section: 2.15
LO: 2.6
GO: G2

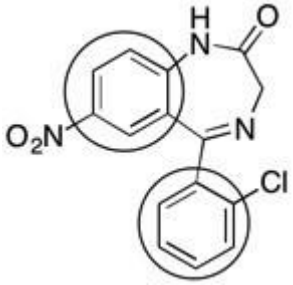
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108) Clonazapam (TM) is used to treat seizures and panic disorders and is shown below. Are there any aromatic hydrocarbons in the molecule? If so, circle them.



Answer: Yes, there are two.



Diff: 1
Section: 2.15
LO: 2.6
GO: G5

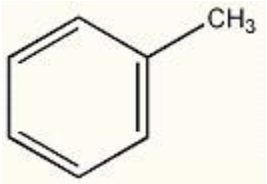
109) Draw the structure of any hydrocarbon alkane which contains 5 carbon atoms.
Answer: $CH_3CH_2CH_2CH_2CH_3$ $(CH_3)_2CHCH_2CH_3$ $(CH_3)_4C$
Diff: 2
Section: 2.15
LO: 2.6

110) Draw the structure of any hydrocarbon alkyne which contains 3 carbon atoms.
Answer:
 or $HC{\equiv}CCH_3$
Diff: 2
Section: 2.15
LO: 2.6
GO: G2
MCAT LO: MCAT3.2

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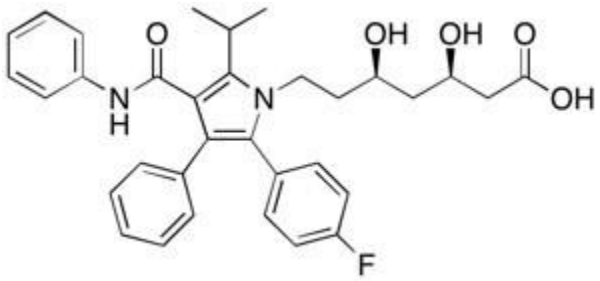
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111) Provide the structure of an aromatic compound with seven carbon atoms.
Answer:



Diff: 2
Section: 2.15
LO: 2.6
GO: G2
MCAT LO: MCAT3.2

112) Choose the functional group which is <u>not</u> represented in the structure of Lipitor (TM).



A) carboxylic acid
B) nitrile
C) aromatic hydrocarbon
D) amide
E) None of the above
Answer: B
Diff: 1
Section: 2.15, 2.16, 2.17
LO: 2.6, 2.7, 2.8
GO: G7

113) Which of the molecules below is an ester?
A) $CH_3CH_2CH(CH_3)_2$
B) $CH_3OCH_2CH_2CH_3$
C) CH_3COOH
D) CH_3COOCH_3
E) $HC{\equiv}CCH_3$
Answer: D
Diff: 1
Section: 2.16
LO: 2.7

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114) Which of the functional groups below contain a hydroxyl group as a part of their structure?
A) aldehyde
B) alcohol
C) carboxylic acid
D) amine
E) B and C only
Answer: E
Diff: 1
Section: 2.16
LO: 2.7

115) Which of the class of organic compound below contains a carbonyl group as a part of its structure?
A) aldehyde
B) ketone
C) carboxylic acid
D) ester
E) all of the above
Answer: E
Diff: 1
Section: 2.16
LO: 2.7

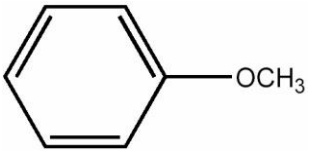
116) Which of the following does not contain a carbonyl group?
A) aldehyde
B) ketone
C) carboxylic acid
D) ester
E) ether
Answer: E
Diff: 1
Section: 2.16
LO: 2.7

117) Which of the following functional groups does not have at least one sp^2 hybridized carbon atom as a constituent of the group?
A) carboxylic acid
B) alkene
C) aldehyde
D) ether
E) ester
Answer: D
Diff: 1
Section: 2.16
LO: 2.7
GO: G2

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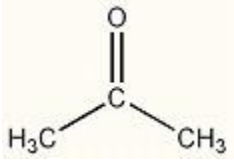
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118) Anisole, the compound shown below, is an example of _____.



A) an ester
B) an ether
C) an alcohol
D) an aldehyde
E) a ketone
Answer: B
Diff: 1
Section: 2.16
LO: 2.7
GO: G2

119) Acetone is a ketone that contains three carbon atoms. Provide its structure.
Answer:



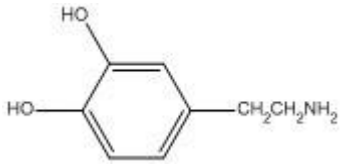
Diff: 1
Section: 2.16
LO: 2.7
GO: G2

120) What is the name of the characteristic functional group found in the molecule $CH_3CH_2CONH_2$?
Answer: It is an amide.
Diff: 1
Section: 2.16
LO: 2.7
GO: G2

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121) Dopamine is shown below. What functional group, or structural element is <u>not</u> present in this compound?



A) hydroxyl
B) amino
C) methylene
D) aromatic ring
E) carboxyl
Answer: E
Diff: 1
Section: 2.15, 2.16, 2.17
LO: 2.6, 2.7, 2.8
GO: G5

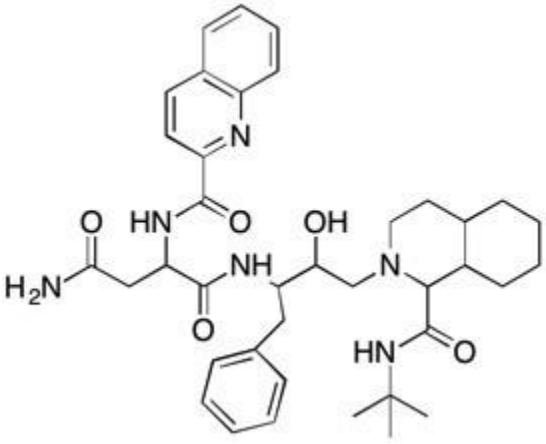
122) Which molecule below is an ether?
A) $CH_3CH_2OCH_2CH_3$
B) $(CH_3)_2CHCH_2OH$
C) $(CH_3)_2CHCH_2NH_2$
D) $(CH_3)_2C{=}CH_2$
E) $CH_3CH_2CH_2CO_2H$
Answer: A
Diff: 1
Section: 2.16
LO: 2.7

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Use the following structure for the two questions below.

Saquinavir Structure



123) Which of the following functional groups is <u>not</u> present in the HIV protease inhibitor drug called Saquinavir?
A) alcohol
B) amide
C) aromatic
D) amine
E) ketone
Answer: E
Diff: 2
Section: 2.15, 2.16, 2.17
LO: 2.6, 2.7, 2.8
GO: G5

124) Which functional group occurs more than two times in the structure of the HIV protease inhibitor drug called Saquinavir?
A) ketone
B) carboxylic acid
C) amine
D) amide
E) alkene
Answer: D
Diff: 2
Section: 2.15, 2.16, 2.17
LO: 2.6, 2.7, 2.8
GO: G5

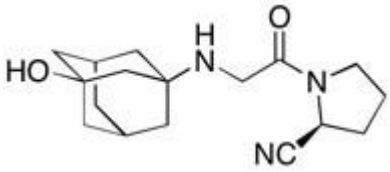
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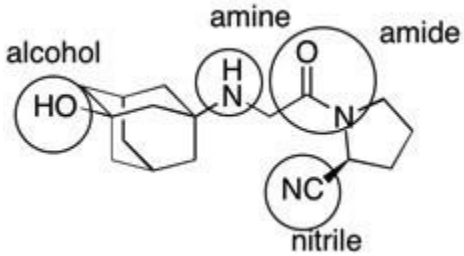
125) Which of the molecules below can be properly called an amine?
A) CH_3CN
B) CH_3COOH
C) $CH_3CH_2CH_2OH$
D) $CH_3CH_2NHCH_3$
E) $CH_3CH_2CH_2NO_2$
Answer: D
Diff: 1
Section: 2.17
LO: 2.8

126) Provide the condensed structures of two structurally isomeric amines that contain two carbons.
Answer: $(CH_3)_2NH$ and $CH_3CH_2NH_2$
Diff: 2
Section: 2.17
LO: 2.8
MCAT LO: MCAT3.2

127) Vildagliptin is a recently released antidiabetic drug (*J. Med. Chem.* **2010**, 7902). Circle and name each functional group in vildagliptin.



Answer:



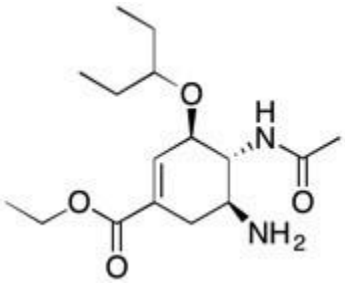
Diff: 2
Section: 2.15, 2.16, 2.17
LO: 2.6, 2.7, 2.8
GO: G5

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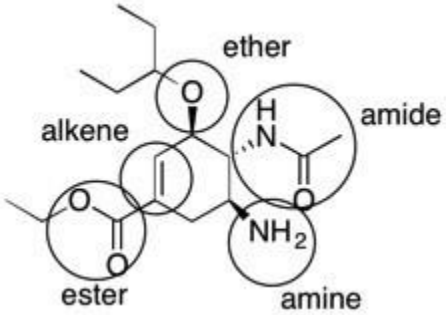
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128) Which molecule below is an alkene?
A) $CH_3CH_2OCH_2CH_3$
B) $(CH_3)_2CHCH_2OH$
C) $(CH_3)_2C{=}CH_2$
D) $(CH_3)_2CHCH_2NH_2$
E) $CH_3CH_2CH_2CO_2H$
Answer: C
Diff: 2
Section: 2.15
LO: 2.6

129) The structure of Tamiflu, an antiinfluenza drug, is shown below (*Organic Lett.* **2007**, 259). Circle and identify each functional group in Tamiflu.



Answer:



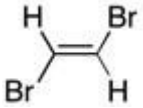
Diff: 3
Section: 2.15, 2.16, 2.17
LO: 2.6, 2.7, 2.8
GO: G5

130) Calculate the charge separation for a C-O bond if the bond distance is 1.43 A and the bond dipole is 0.86 D.
Answer: $\mu = 4.8 \times \delta \times$ distance
$\delta = 0.125$ e-
Diff: 3
Section: 2.1
GO: G4
MCAT LO: MCAT2.6

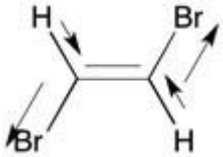
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131) Consider 1,2-dibromoethene, shown below. Use arrows to represent the individual bond dipoles. Would you expect this molecule to be polar? Briefly explain your reasoning.



Answer:

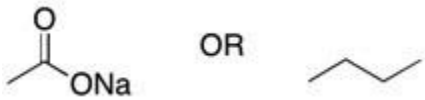


No, you would not expect this molecule to be polar. The dipoles all are pointing in opposite directions and cancel each other out.
Diff: 3
Section: 2.1
LO: 2.5
MCAT LO: MCAT2.6

132) Why doesn't a salt like KCl dissolve in hexane ($CH_3(CH_2)_4CH_3$), a non-polar solvent?

Answer: The nonpolar molecules of these solvents do not solvate ions very strongly, and they cannot overcome the large lattice energy of the salt crystal. This is a case where the attractions of the ions in the solid for each other are much greater than their attractions for the solvent.
Diff: 3
Section: 2.3
LO: 2.5
MCAT LO: MCAT2.5

133) Which is more soluble in water?



Answer: The first structure. It is a salt and can dissociate in to two charged ions which will be solvated by the water. Butane (the second structure) is non-polar.
Diff: 3
Section: 2.3
LO: 2.5
MCAT LO: MCAT2.5

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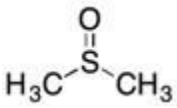
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134) Sodium hydride (NaH) is a base that is commonly used in organic reactions. The pKa of H_2 is 36. Which of the following compounds could <u>not</u> be used as a solvent if you were using NaH?

A)



B)

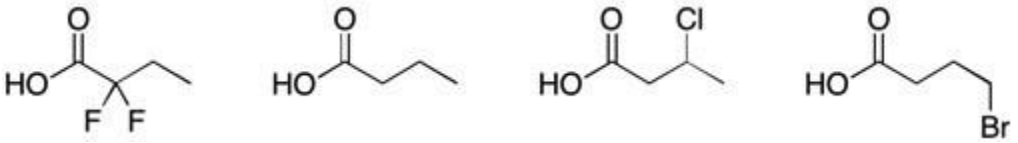


C) CH_3CH_2OH

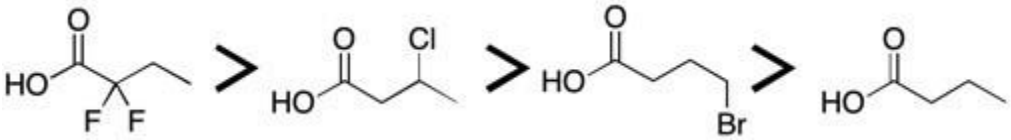
D) $CH_3CH_2CH_2CH_2CH_3CH_3$

Answer: C
Diff: 2
Section: 2.8
LO: 1.6

135) Rank the following compounds in order of acidity.



Answer:



Diff: 3
Section: 2.10
LO: 1.6

136) Explain why the pKa of acetylene is 25, while that of ethene is 44.

$HC{\equiv}CH$ vs $H_2C{=}CH_2$
acetylene ethene

Answer: The hybridization of the C in acetylene is sp while the carbons in ethene are sp^2. The orbital in acetylene has more s character, which causes it to be closer to the nucleus. This stabilizes the conjugate base of acetylene more.
Diff: 3
Section: 2.10
LO: 1.6

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