

Chapter One

MULTIPLE CHOICE QUESTIONS

Topic: General

Section: 1.1

Difficulty Level: Easy

1. Credit for the first synthesis of an organic compound from an inorganic precursor is usually given to:

- A) Berzelius
- B) Arrhenius
- C) Kekule
- D) Wohler
- E) Lewis

Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.2

Difficulty Level: Easy

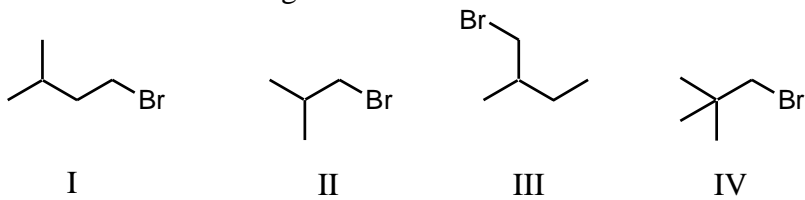
2. How many sigma $1s-2sp^3$ bonds are there in ethane?

- A) 7
- B) 6
- C) 5
- D) 3
- E) 1

Ans: B

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

3. Which of the following is a set of constitutional isomers?



- A) I and II
- B) II and III
- C) I, II, and III
- D) II, III, and IV
- E) I, III, and IV

Ans: E

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

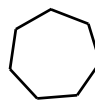
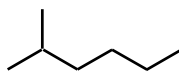
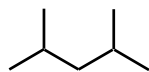
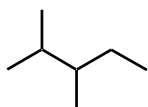
4. $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ are examples of what are now termed:

- A) Structural isomers
- B) Resonance structures
- C) Functional isomers
- D) Empirical isomers
- E) Constitutional isomers

Ans: E

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

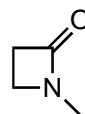
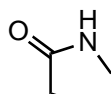
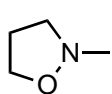
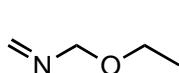
5. Which of the following structures represent compounds that are constitutional isomers of each other?



- A) I and II
 - B) I and III
 - C) I, II, and III
 - D) I, II, III, and IV
 - E) II and III
- Ans: C

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

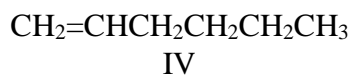
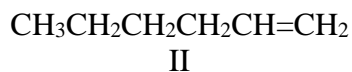
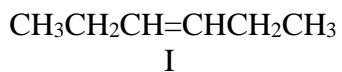
6. Which compound is not a constitutional isomer of the others?



- A) I
 - B) II
 - C) III
 - D) IV
 - E) All of the above are isomers of each other.
- Ans: D

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

7. Consider the following:



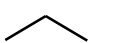

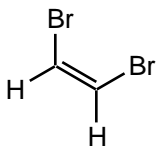
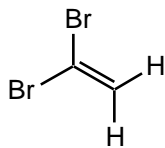
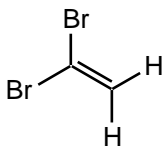
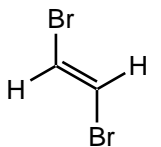
Which two structures represent the same compound?

- A) I and II
- B) II and III
- C) I and III
- D) II and IV
- E) None of these

Ans: D

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

8. Which of the following represent a pair of constitutional isomers?

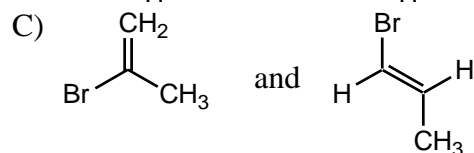
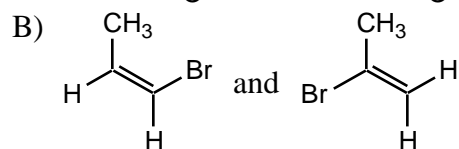
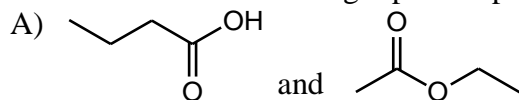
- A)  and 
- B) $\text{CH}_3\text{CH}=\text{CH}_2$ and $\text{CH}_2=\text{CHCH}_3$
- C)  and 
- D)  and 

E) More than one of these

Ans: E

Topic: Isomerism
Section: 1.3
Difficulty Level: Easy

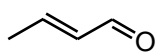
9. Which of the following represent pairs of constitutional isomers?



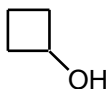
- D) None of these pairs
E) All of these pairs
Ans: D

Topic: Isomerism
Section: 1.3
Difficulty Level: Medium

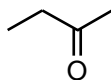
10. Which compound is not a constitutional isomer of the others?



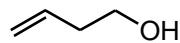
I



II



III



IV

- A) I
B) II
C) III
D) IV
E) All of the above are isomers of each other.

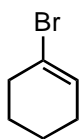
Ans: A

Topic: Isomerism

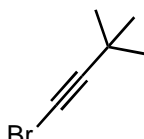
Section: 1.3

Difficulty Level: Medium

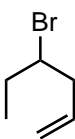
11. Which compound is not a constitutional isomer of the others?



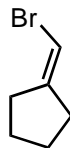
I



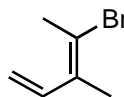
II



III



IV



V

- A) I and II
- B) II
- C) III
- D) IV and V
- E) All of the above are isomers of each other.

Ans: C

Topic: Atomic Orbitals, Periodic Trends, Electronegativity

Section: 1.4

Difficulty Level: Easy

12. The greatest degree of ionic character is anticipated for the bond between:

- A) H and C
- B) H and Cl
- C) C and Cl
- D) H and Br
- E) Br and Cl

Ans: B

Topic: Periodic Trends, Electronegativity

Section: 1.4

Difficulty Level: Easy

13. Select the least electronegative element from the list below:

- A) P
- B) N
- C) Mg
- D) Si
- E) K

Ans: E

Topic: Periodic Properties, Electronegativity

Section: 1.4A

Difficulty Level: Easy

14. Select the most electronegative element from the list below:

- A) H
- B) O
- C) N
- D) B
- E) C

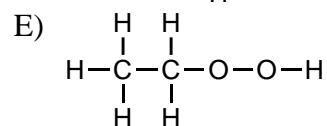
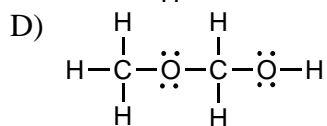
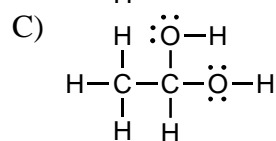
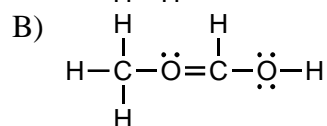
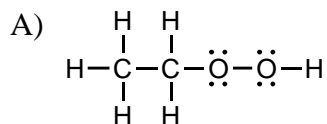
Ans: B

Topic: Lewis Structures

Section: 1.5

Difficulty Level: Medium

15. Which of the following is the Lewis structure for $\text{CH}_3\text{CH}_2\text{O}_2\text{H}$?



Ans: A

Topic: Lewis Structures

Section: 1.5

Difficulty Level: Medium

16. In which of the following does the central atom have 2 pairs of non-bonding electrons?

- A) O_3
- B) CO_2
- C) CO_3^{2-}
- D) NH_4^+
- E) H_2S

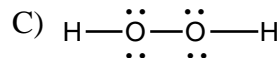
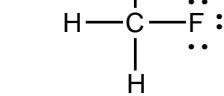
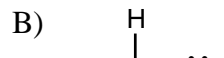
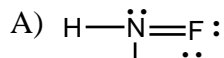
Ans: E

Topic: Lewis Structures, Formal Charges

Section: 1.5

Difficulty Level: Medium

17. Which is NOT a correct Lewis structure?



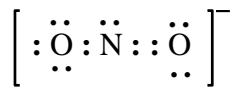
Ans: A

Topic: Lewis Structures, Formal Charges

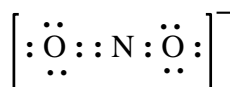
Section: 1.5

Difficulty Level: Medium

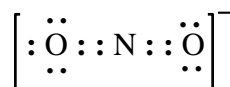
18. Which of these is a correct electron-dot representation of the nitrite ion, NO_2^- ?



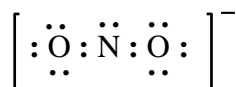
I



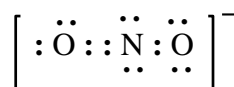
II



III



IV



V

- A) I
- B) II
- C) III
- D) IV
- E) V

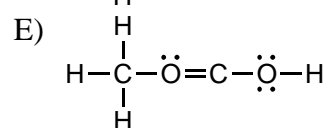
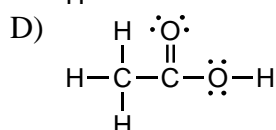
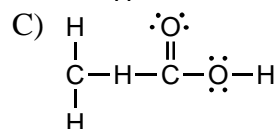
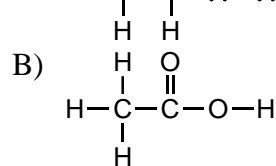
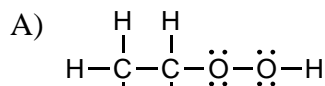
Ans: A

Topic: Lewis Structures

Section: 1.5

Difficulty Level: Hard

19. Which of the following is the Lewis structure for $\text{CH}_3\text{CO}_2\text{H}$?



Ans: D

Topic: Lewis Structures

Section: 1.5

Difficulty Level: Hard

20. Considering Lewis structures, which of these compounds possesses a single unpaired electron?

- A) N_2
- B) N_2O
- C) NO
- D) N_2O_4
- E) O_2

Ans: C

Topic: Lewis Structures

Section: 1.5

Difficulty Level: Hard

21. $\text{Y} \begin{array}{c} \ddot{\text{Z}} \\ \diagup \quad \diagdown \\ \text{Y} \end{array}$ is a generalized structural representation which can be used for all of the following, except:

- A) OF_2
- B) NH_2^-
- C) H_2S
- D) BeBr_2
- E) There is no exception.

Ans: D

Topic: Lewis Structures, Formal Charges

Section: 1.6

Difficulty Level: Easy

22. Expansion of the valence shell to accommodate more than eight electrons is possible with:

- A) Fluorine
- B) Nitrogen
- C) Carbon
- D) Sulfur
- E) Beryllium

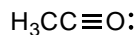
Ans: D

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

23. What is the formal charge on oxygen in the following structure?



- A) +2
- B) +1
- C) 0
- D) -1
- E) -2

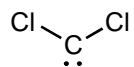
Ans: B

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

24. What is the formal charge on carbon in the following structure?



- A) +2
- B) +1
- C) 0
- D) -1
- E) -2

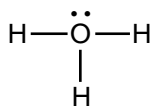
Ans: C

Topic: Lewis Structures, Formal Charges

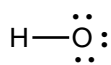
Section: 1.7

Difficulty Level: Easy

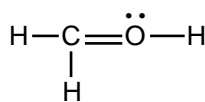
25. In which structure(s) below does the oxygen have a formal charge of +1?



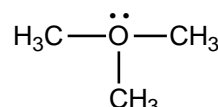
I



II



III



IV

- A) I only
- B) II only
- C) I and III
- D) I and IV
- E) I, III, and IV

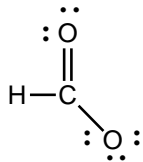
Ans: E

Topic: Lewis Structures, Formal Charges

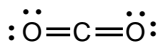
Section: 1.7

Difficulty Level: Easy

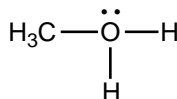
26. Which structure(s) contain(s) an oxygen that bears a formal charge of +1?



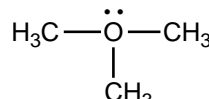
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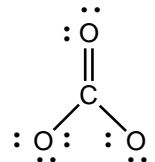
II



III



IV



V

- A) I and II
- B) III and IV
- C) V
- D) II
- E) I and V

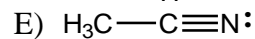
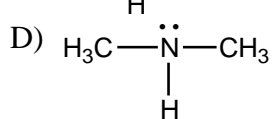
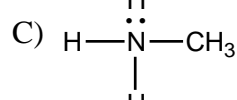
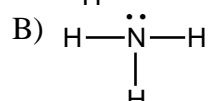
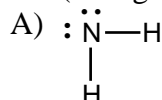
Ans: B

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

27. Which of the following molecules or ions has a nitrogen with a formal charge of -1?
(Charges on ions have been omitted.)



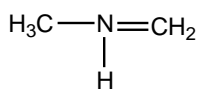
Ans: A

Topic: Lewis Structures, Formal Charges

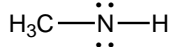
Section: 1.7

Difficulty Level: Easy

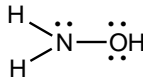
28. In which structure(s) below does nitrogen have a formal charge of +1?



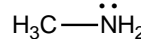
I



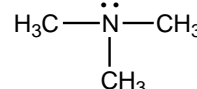
II



III



IV



V

- A) I
- B) II and IV
- C) III and V
- D) I and V
- E) V

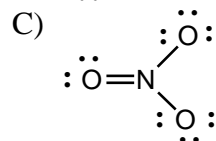
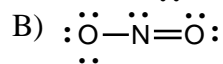
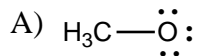
Ans: A

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

29. Which of the following is an ion with a single negative charge?



- D) All of these
- E) None of these

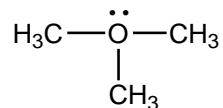
Ans: D

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

30. What is the formal charge on oxygen in the following structure?



- A) +2
- B) +1
- C) 0
- D) -1
- E) -2

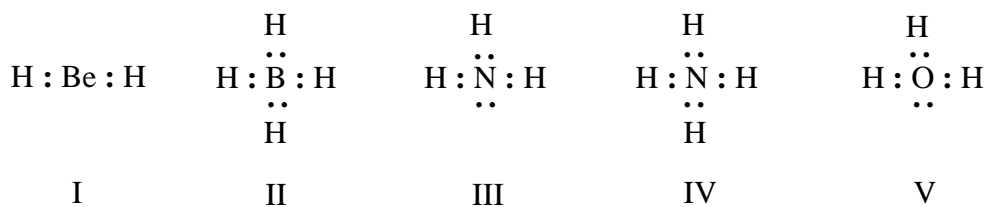
Ans: B

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

31. Listed below are electron dot formulas for several simple molecules and ions. All valence electrons are shown; however, electrical charges have been omitted deliberately.



Which of the structures actually bear(s) a positive charge?

- A) I
- B) II
- C) III
- D) III & V
- E) IV & V

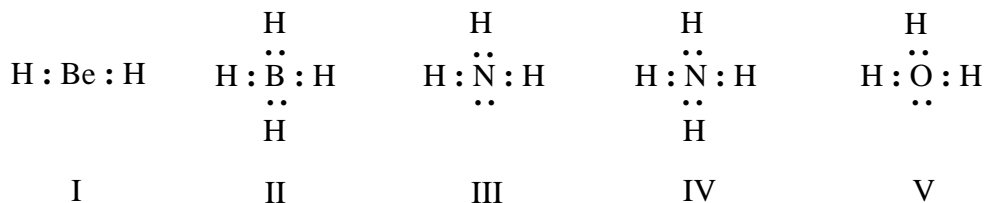
Ans: E

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

32. Listed below are electron dot formulas for several simple molecules and ions. All valence electrons are shown; however, electrical charges have been omitted deliberately.



Which of the structures is negatively charged?

- A) I
- B) II
- C) III
- D) IV
- E) V

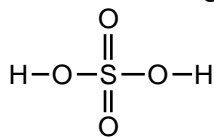
Ans: B

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Easy

33. The formal charge on sulfur in sulfuric acid is:



- A) 0
- B) -1
- C) +1
- D) -2
- E) +2

Ans: A

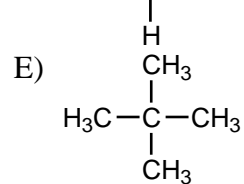
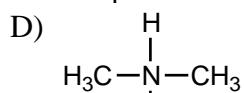
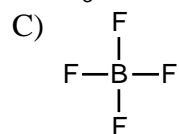
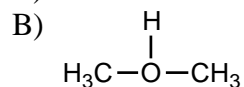
Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Medium

34. In which of these cases does the central atom have a zero formal charge?

A) HFH



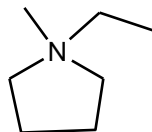
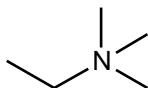
Ans: E

Topic: Lewis Structures, Formal Charges

Section: 1.7

Difficulty Level: Medium

35. Which compound contains a nitrogen atom with a formal positive charge?



I

II

III

A) I

B) II

C) III

D) More than one of the above

E) None of the above

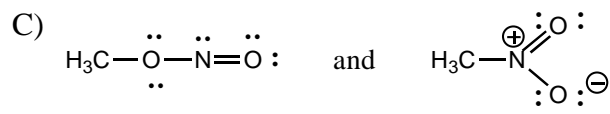
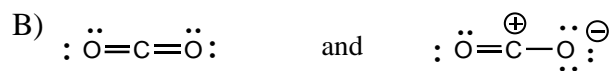
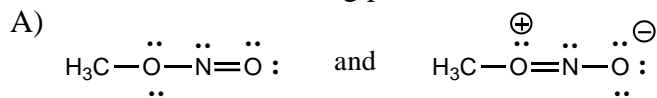
Ans: D

Topic: Atomic Orbitals, Lewis Structures, Resonance

Section: 1.8

Difficulty Level: Easy

36. Which of the following pairs are NOT resonance structures?



D) Each of these pairs represents resonance structures.

E) None of these pairs represents resonance structures.

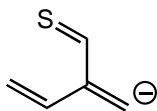
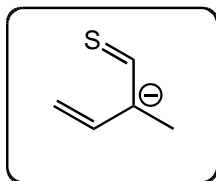
Ans: C

Topic: Resonance

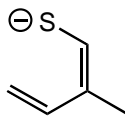
Section: 1.8

Difficulty Level: Medium

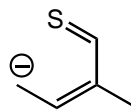
37. Which of the following species is/are **not** a resonance form(s) of the anionic species in the box?



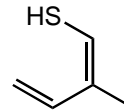
I



II



III



IV

A) I

B) II and III

C) III and IV

D) I and IV

E) I and III

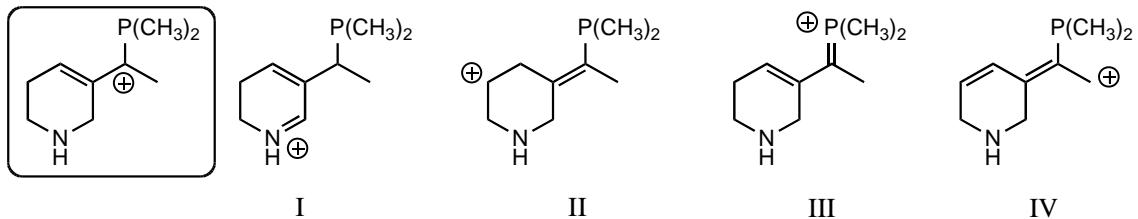
Ans: D

Topic: Resonance

Section: 1.8

Difficulty Level: Medium

38. Which of the following species is a resonance form of the species in the box?



- A) I
- B) II
- C) III
- D) IV
- E) None of the above are correct resonance forms.

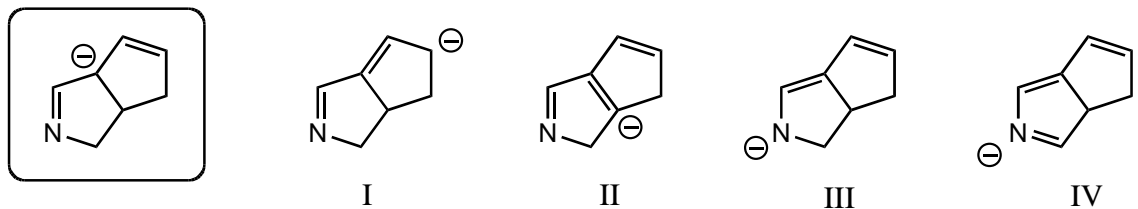
Ans: C

Topic: Resonance

Section: 1.8

Difficulty Level: Medium

39. Which of the following species is/are a resonance form(s) of the species in the box?



- A) I and II
- B) I and III
- C) III and IV
- D) III
- E) More than two of them are correct resonance forms.

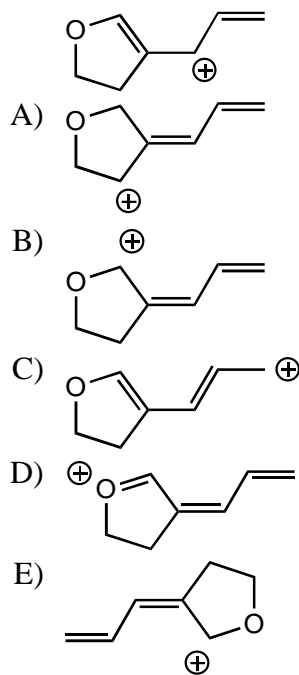
Ans: B

Topic: Resonance

Section: 1.8

Difficulty Level: Medium

40. Which of the following species is *not* a resonance form of the following species?



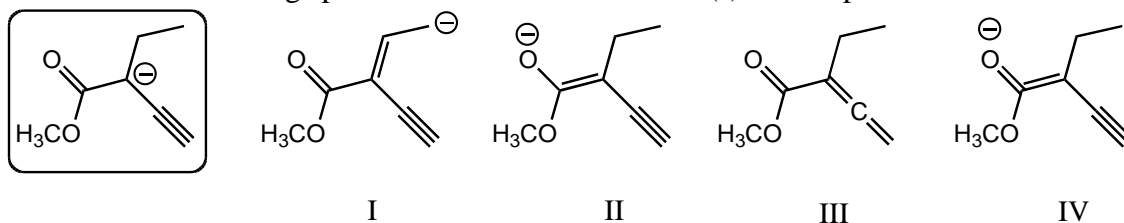
Ans: A

Topic: Resonance

Section: 1.8

Difficulty Level: Medium

41. Which of the following species is/are a resonance form(s) of the species in the box?



- A) I and II
B) II and III
C) III
D) II
E) More than two of them are correct resonance forms.

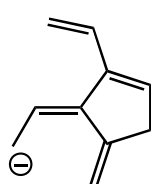
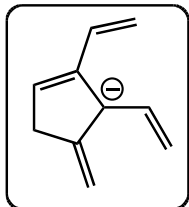
Ans: D

Topic: Resonance

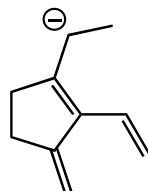
Section: 1.8

Difficulty Level: Medium

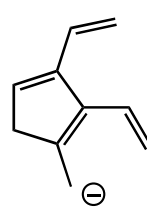
42. Which of the following species is/are **not** a resonance form(s) of the species in the box?



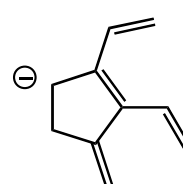
I



II



III



IV

A) I

B) II

C) III

D) IV

E) More than two of them are incorrect resonance forms.

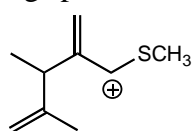
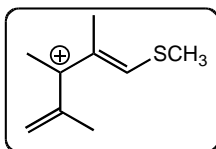
Ans: B

Topic: Resonance

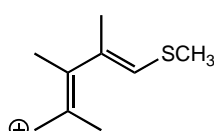
Section: 1.8

Difficulty Level: Medium

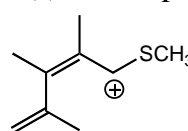
43. Which of the following species is/are **not** a resonance form(s) of the species in the box?



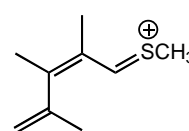
I



II



III



IV

A) I

B) II

C) III

D) IV

E) More than two of them are incorrect resonance forms.

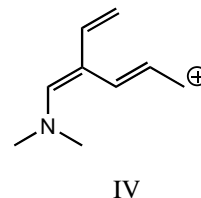
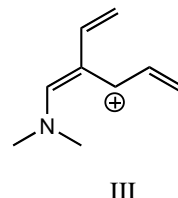
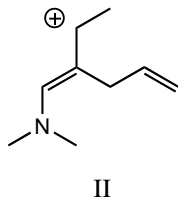
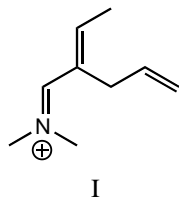
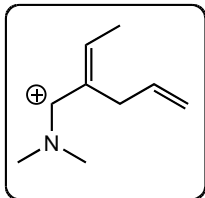
Ans: A

Topic: Resonance

Section: 1.8

Difficulty Level: Medium

44. Which of the following species is/are **not** a resonance form(s) of the species in the box?



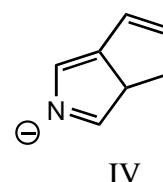
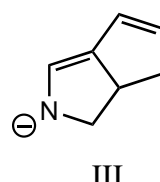
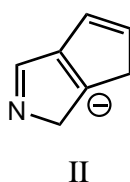
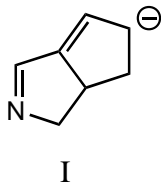
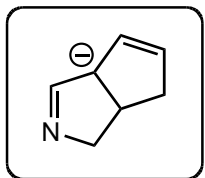
- A) I and II
B) II and III
C) III and IV
D) I and IV
E) II and IV
Ans: C

Topic: Resonance

Section: 1.8

Difficulty Level: Medium

45. Which of the following species contributes more to the overall hybrid for the species in the box?



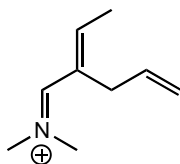
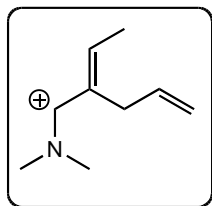
- A) I
B) II
C) III
D) IV
E) The one in the box.
Ans: C

Topic: Resonance

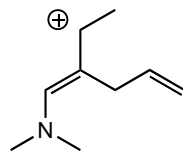
Section: 1.8

Difficulty Level: Medium

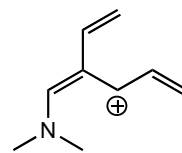
46. Which of the following species contributes more to the overall hybrid for the species in the box?



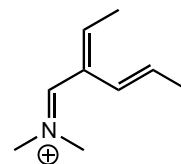
I



II



III



IV

- A) I
B) II
C) III
D) IV
E) The one in the box.

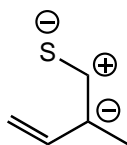
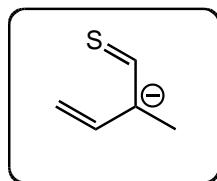
Ans: A

Topic: Resonance

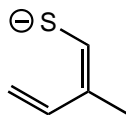
Section: 1.8

Difficulty Level: Medium

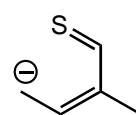
47. Which of the following species contributes more to the overall hybrid for the species in the box?



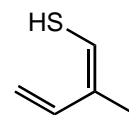
I



II



III



IV

- A) I
B) II
C) III
D) IV
E) The one in the box.

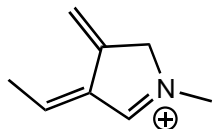
Ans: B

Topic: Resonance

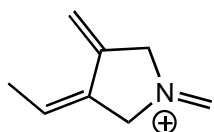
Section: 1.8

Difficulty Level: Hard

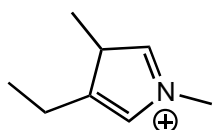
48. Which of the following species is a resonance form of the following species?



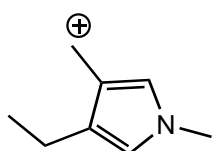
A)



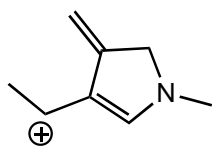
B)



C)



D)



E) All the above are correct resonance forms.

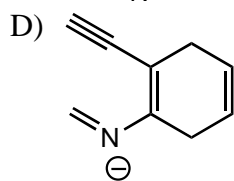
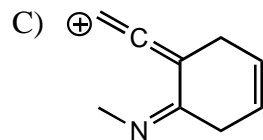
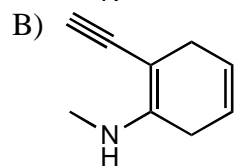
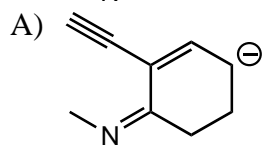
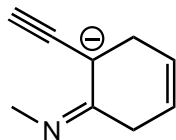
Ans: D

Topic: Resonance

Section: 1.8

Difficulty Level: Hard

49. Which of the following structures is/are **not** a resonance form of the following species?

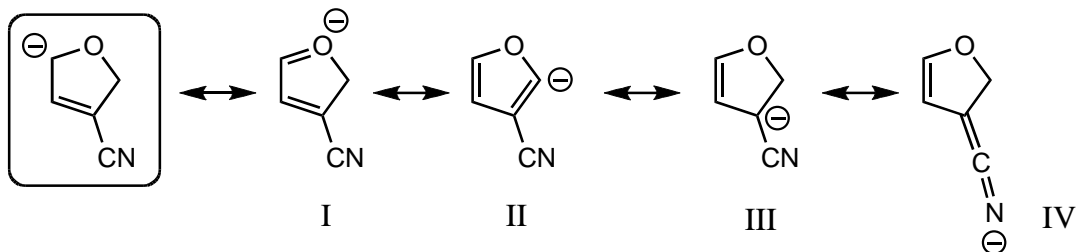


E) None of the above are correct resonance forms.

Ans: E

Topic: Resonance
 Section: 1.8
 Difficulty Level: Hard

50. Which of the following species are resonance forms of the species in the box?

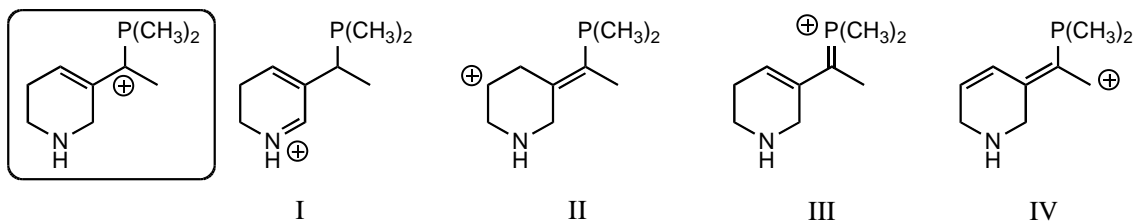


- A) I and III
- B) I and II
- C) III and IV
- D) II and IV
- E) All of the above are correct resonance forms.

Ans: C

Topic: Resonance
 Section: 1.8
 Difficulty Level: Hard

51. Which of the following species contributes more to the overall hybrid for the species in the box?

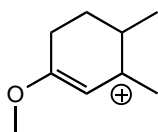
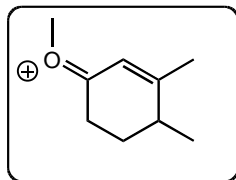


- A) I
- B) II
- C) III
- D) IV
- E) The one in the box.

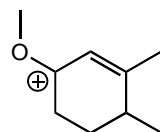
Ans: C

Topic: Resonance
 Section: 1.8
 Difficulty Level: Hard

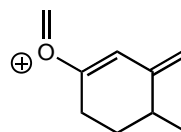
52. Which of the following species contributes more to the overall hybrid for the species in the box?



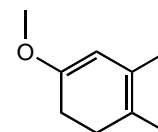
I



II



III



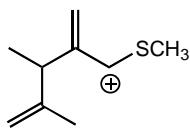
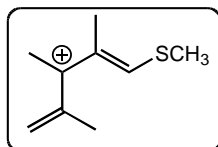
IV

- A) I
- B) II
- C) III
- D) IV
- E) The one in the box.

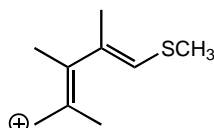
Ans: E

Topic: Resonance
 Section: 1.8
 Difficulty Level: Hard

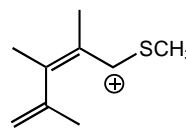
53. Which of the following species contributes more to the overall hybrid for the species in the box?



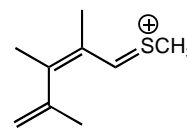
I



II



III



IV

- A) I
- B) II
- C) III
- D) IV
- E) The one in the box.

Ans: D

Topic: Atomic Orbitals, Lewis structures, Resonance

Section: 1.8

Difficulty Level: Medium

54. Which of the structures below is not expected to contribute to the CO_2 resonance hybrid?

- A) $\text{O}=\overset{+}{\text{C}}-\overset{-}{\text{O}}$
B) $\overset{-}{\text{O}}-\overset{+}{\text{C}}=\text{O}$
C) $\text{O}=\text{C}=\text{O}$
D) $\overset{-}{\text{O}}-\overset{+}{\text{C}}\overset{+}{\text{C}}-\overset{-}{\text{O}}$
E) $\overset{-}{\text{O}}-\text{C}\equiv\overset{+}{\text{O}}$

Ans: D

Topic: Atomic orbitals, Lewis structures, resonance

Section: 1.5 and 1.8

Difficulty Level: Medium

55. Which of the following could not be a resonance structure of CH_3NO_2 ?

- A) $\begin{array}{c} \text{H} \quad \text{:}\ddot{\text{O}}\text{:}\ominus \\ | \quad // \\ \text{H}-\text{C}-\text{N}^{\oplus} \\ | \quad \backslash \\ \text{H} \quad \text{:}\ddot{\text{O}}\text{:} \end{array}$
B) $\begin{array}{c} \text{H} \quad \text{:}\ddot{\text{O}}\text{:} \\ | \quad // \\ \text{H}-\text{C}-\text{N}^{\oplus} \\ | \quad \backslash \\ \text{H} \quad \text{:}\ddot{\text{O}}\text{:}\ominus \end{array}$
C) $\begin{array}{c} \text{H} \quad \text{:}\ddot{\text{O}}\text{:}\ominus \\ | \quad // \\ \text{H}-\text{C}-\text{N}^{\oplus 2} \\ | \quad \backslash \\ \text{H} \quad \text{:}\ddot{\text{O}}\text{:}\ominus \end{array}$
D) $\begin{array}{c} \text{H} \quad \text{:}\ddot{\text{O}}\text{:}\ominus \\ \backslash \quad // \\ \text{C}=\text{N}^{\oplus} \\ / \quad \backslash \\ \text{H} \quad \text{:}\ddot{\text{O}}\text{:}-\text{H} \end{array}$

E) Both C and D

Ans: D

Topic: Atomic Orbitals, Lewis Structures, Resonance

Section: 1.5 and 1.8

Difficulty Level: Medium

56. How many resonance structures can be written for the NO_3^- ion in which the nitrogen atom bears a formal charge of +1?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

Ans: C

Topic: Resonance

Section: 1.5 and 1.8

Difficulty Level: Medium

57. Which of the following species exhibits resonance stabilization?

- A) H_2SO_4
- B) O_3
- C) CO_2
- D) CCl_4
- E) None of the species above exhibit resonance.

Ans: B

Topic: Atomic Orbitals

Section: 1.9

Difficulty Level: Easy

58. In quantum mechanics a node (nodal surface or plane) is:

- A) a place where Ψ is negative.
- B) a place where Ψ is positive.
- C) a place where $\Psi = 0$.
- D) a place where Ψ^2 is large.
- E) a place where Ψ^2 is negative.

Ans: C

Topic: Atomic Orbitals

Section: 1.10A

Difficulty Level: Easy

59. Which principle(s) or rule(s) must be used to determine the correct electronic configuration for carbon in its ground state?

- A) Aufbau Principle
- B) Hund's Rule
- C) Pauli Exclusion Principle
- D) (A) and (B) only
- E) All three

Ans: E

Topic: Atomic Orbitals, Molecular Orbitals

Section: 1.11

Difficulty Level: Easy

60. When the $1s$ orbitals of two hydrogen atoms combine to form a hydrogen molecule, how many molecular orbitals are formed?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

Ans: B

Topic: Atomic Orbitals, Molecular Orbitals

Section: 1.11

Difficulty Level: Easy

61. When the $1s$ orbitals of two hydrogen atoms combine to form a hydrogen molecule, which molecular orbitals are formed?

- A) One bonding molecular orbital only
- B) Two bonding molecular orbitals
- C) One bonding molecular orbital and one antibonding molecular orbital
- D) Two antibonding molecular orbitals
- E) Three bonding molecular orbitals

Ans: C

Topic: Atomic orbitals, molecular orbitals

Section: 1.11

Difficulty Level: Easy

62. When the $1s$ orbitals of two hydrogen atoms combine to form a hydrogen molecule, how are the electrons distributed in the resulting molecular orbitals?
- A) 2 electrons in the bonding molecular orbital
 - B) 1 electron in the bonding molecular orbital, 1 electron in the non-bonding molecular orbital
 - C) 1 electron in the bonding molecular orbital, 1 electron in the antibonding molecular orbital
 - D) 2 electrons in the non-bonding molecular orbital
 - E) 2 electrons in the antibonding molecular orbital

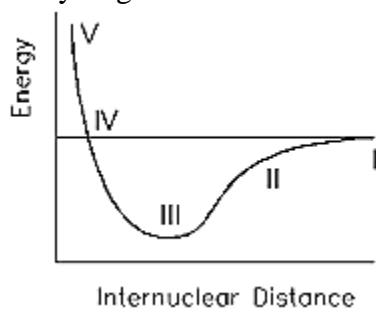
Ans: A

Topic: Atomic Orbitals, Bonding

Section: 1.11

Difficulty Level: Easy

63. What point on the potential energy diagram below represents the most stable state for the hydrogen molecule?



- A) I
- B) II
- C) III
- D) IV
- E) V

Ans: C

Topic: Atomic Orbitals, Molecular Orbitals

Section: 1.11

Difficulty Level: Medium

64. According to molecular orbital theory, which molecule could not exist?

- A) H_2
- B) He_2
- C) Li_2
- D) F_2
- E) N_2

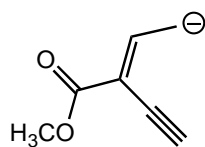
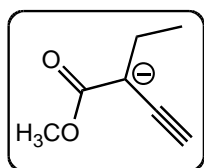
Ans: B

Topic: Resonance

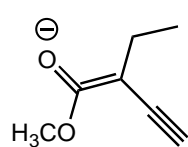
Section: 1.11

Difficulty Level: Medium

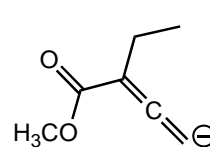
65. Which of the following species contributes more to the overall hybrid for the species in the box?



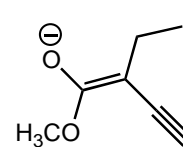
I



II



III



IV

- A) I
- B) II
- C) III
- D) IV
- E) The one in the box.

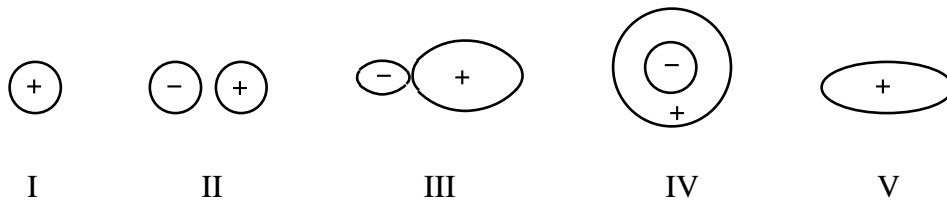
Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.12

Difficulty Level: Easy

66. Select the hybridized atomic orbital.



- A) I
- B) II
- C) III
- D) IV
- E) V

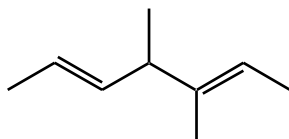
Ans: C

Topic: Atomic Orbitals, Hybridization

Section: 1.12

Difficulty Level: Easy

67. How many $s-sp^3$ bonds are there in the following substance?



- A) 3
- B) 8
- C) 12
- D) 13
- E) 16

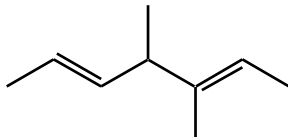
Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.13

Difficulty Level: Easy

68. How many $s-sp^2$ bonds are there in the following substance?



- A) 2
- B) 3
- C) 4
- D) 5
- E) 12

Ans: B

Topic: Atomic Orbitals, Molecular Orbitals

Section: 1.13

Difficulty Level: Medium

69. According to molecular orbital theory, in the case of a carbon-carbon double bond, the carbon-carbon bonding electrons of higher energy occupy this molecular orbital:

- A) σ bonding MO
- B) π bonding MO
- C) σ^* antibonding MO
- D) π^* antibonding MO
- E) π^* bonding MO

Ans: B

Topic: Isomerism

Section: 1.13B

Difficulty Level: Easy

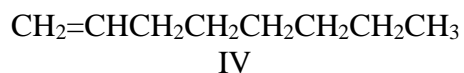
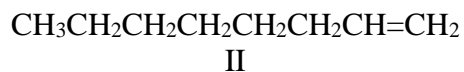
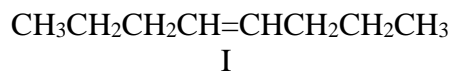
70. cis-trans: isomerism is possible only in the case of:

- A) $\text{CH}_2=\text{CBr}_2$
- B) $\text{CH}_2=\text{CHBr}$
- C) $\text{BrCH}=\text{CHBr}$
- D) $\text{Br}_2\text{C}=\text{CHBr}$
- E) $\text{Br}_2\text{C}=\text{CBr}_2$

Ans: C

Topic: Isomerism
Section: 1.13B
Difficulty Level: Easy

71. Consider the following:



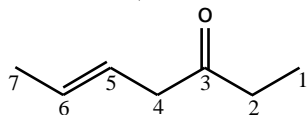
Which structures can exist as cis-trans: isomers?

- A) I and II
- B) I and III
- C) I and IV
- D) II and III
- E) I alone

Ans: B

Topic: General, Bonding
Section: 1.12 and 1.13
Difficulty Level: Easy

72. The C4-C5 carbon-carbon bond in the following molecule results from the overlap of which orbitals (in the order C4-C5) ?



- A) $sp-sp^2$
- B) $sp-sp^3$
- C) sp^2-sp^2
- D) sp^2-sp^3
- E) sp^3-sp^2

Ans: E

Topic: Atomic Orbitals, Hybridization

Section: 1.14

Difficulty Level: Easy

73. Identify the atomic orbitals in the C-C sigma bond in ethyne.

- A) ($2sp^2$, $2sp^2$)
- B) ($2sp^3$, $2sp^3$)
- C) ($2sp$, $2sp$)
- D) ($2p$, $2p$)
- E) ($2sp$, $1s$)

Ans: C

Topic: Atomic Orbitals, Hybridization

Section: 1.14

Difficulty Level: Easy

74. Identify the atomic orbitals in the C-H sigma bond in acetylene.

- A) ($2sp^2$, $1s$)
- B) ($2sp^3$, $2sp^3$)
- C) ($2sp$, $2sp$)
- D) ($2p$, $2p$)
- E) ($2sp$, $1s$)

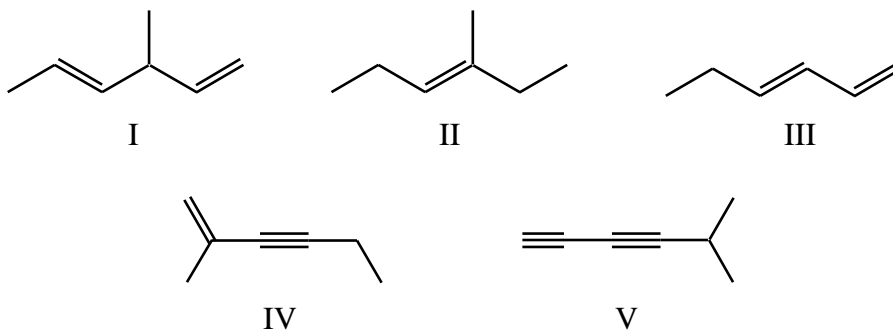
Ans: E

Topic: Bonding, Atomic Orbitals, Hybridization

Section: 1.14A

Difficulty Level: Easy

75. Which molecule has the shortest carbon-carbon single bond?



- A) I
- B) II
- C) III
- D) IV
- E) V

Ans: E

Topic: Atomic orbitals, hybridization

Section: 1.12, 1.13, and 1.14

Difficulty Level: Easy

76. Which compound has the shortest carbon-carbon bond(s)?

- A) CH_3CH_3
- B) $\text{CH}_2=\text{CH}_2$
- C) $\text{HC}\equiv\text{CH}$
- D) $\text{CH}_3\text{CH}_2\text{CH}_3$
- E) All carbon-carbon bonds are the same length.

Ans: C

Topic: Atomic Orbitals, Hybridization

Section: 1.12, 1.13, and 1.14

Difficulty Level: Medium

77. Which is the shortest of the carbon-carbon single bonds indicated by arrows in the following compounds?

- A) $\begin{array}{c} \downarrow \\ \text{H}_3\text{C}-\text{CH}_3 \end{array}$
- B) $\begin{array}{c} \downarrow \\ \text{H}_3\text{C}-\text{C}\equiv\text{CH} \end{array}$
- C) $\begin{array}{c} \downarrow \quad \text{CH}_2 \\ \text{H}_3\text{C}-\text{CH} \end{array}$
- D) $\begin{array}{c} \downarrow \\ \text{HC}\equiv\text{C}-\text{C}\equiv\text{CH} \end{array}$
- E) $\begin{array}{c} \text{H}_2\text{C} \\ \parallel \\ \text{HC}-\text{C}\equiv\text{CH} \\ \downarrow \end{array}$

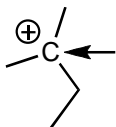
Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Easy

78. What is the hybridization of the C indicated with the arrow?



- A) sp^3
- B) sp^2
- C) sp
- D) s
- E) p

Ans: B

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Easy

79. Which of the following contains an sp^2 -hybridized carbon?

- A) CH_4
- B) CH_3^-
- C) CH_3CH_3
- D) CH_3^+
- E) $HC\equiv CH$

Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Easy

80. How many $2p$ atomic orbitals from boron must be mixed with a $2s$ atomic orbital to yield the bonding hybrid atomic orbitals in BF_3 ?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

Ans: B

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Easy

81. Identify the atomic orbital. The lone pair electrons on the B atom are contained in:



- A) $2sp^2$
- B) $2sp^3$
- C) $2p$
- D) $2s$
- E) There are no lone pair electrons on B

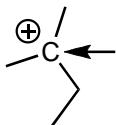
Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Easy

82. What is the geometry of the C indicated with the arrow?



- A) tetrahedral
- B) trigonal pyramidal
- C) linear
- D) bent
- E) trigonal planar

Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Easy

83. What geometry does the methyl cation, CH_3^+ , have?

- A) Octahedral
- B) Tetrahedral
- C) Trigonal planar
- D) Linear
- E) Trigonal pyramidal

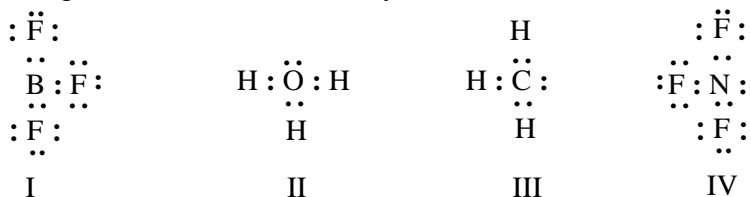
Ans: C

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Easy

84. Which of the structures below would be trigonal planar (a planar triangle)? (Electrical charges have been deliberately omitted.)



- A) I
- B) II
- C) III
- D) IV
- E) I and IV

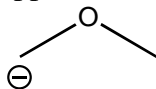
Ans: A

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Easy

85. The bond angle for the C-O-C bonds in the following molecule would be expected to be approximately:



- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

Ans: B

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Easy

86. The bond angles for the **bold-faced C** in $\text{CH}_3\text{CH}_2\text{C}^+\text{H}_2$ would be expected to be approximately:

- A) 60°
- B) 90°
- C) 105°
- D) 109°
- E) 120°

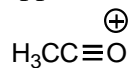
Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Easy

87. The bond angle for the C-C-O bonds in the following molecule would be expected to be approximately:



- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

Ans: E

Topic: Molecular Geometry

Section: 1.16

Difficulty Level: Easy

88. What bond angle is associated with a tetrahedral molecule?

- A) 120°
- B) 109.5°
- C) 180°
- D) 90°
- E) 45°

Ans: B

Topic: Hybridization
Section: 1.16
Difficulty Level: Easy

89. What is the approximate hybridization state of the oxygen molecule in ethanol, C_2H_5OH ?
- A) sp
 - B) sp^2
 - C) sp^3
 - D) p^3
 - E) d^2sp^3
- Ans: C

Topic: Hybridization
Section: 1.16
Difficulty Level: Easy

90. What is the approximate hybridization state of the nitrogen atom in trimethylamine, $(CH_3)_3N$?
- A) sp
 - B) sp^2
 - C) sp^3
 - D) p^3
 - E) d^2sp^3
- Ans: C

Topic: Lewis structures, Hybridization
Section: 1.16
Difficulty Level: Easy

91. Which molecule has a non-linear shape (i.e., for which molecule are the nuclei not in a straight line)?
- A) $O=C=O$
 - B) $H-O-H$
 - C) $H-Cl$
 - D) $H-C\equiv N$
 - E) $H-C\equiv C-H$
- Ans: B

Topic: Molecular Geometry

Section: 1.16

Difficulty Level: Medium

92. What would be the spatial arrangement (shape) of the atoms of the methyl anion, $:\text{CH}_3^-$?

- A) Octahedral
- B) Tetrahedral
- C) Trigonal planar
- D) Linear
- E) Trigonal pyramidal

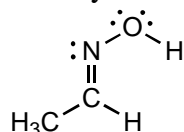
Ans: E

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

93. Identify the atomic orbitals in the C-N sigma bond in the following oxime:



- A) ($2sp^2$, $2sp^2$)
- B) ($2sp^3$, $2sp^3$)
- C) ($2sp$, $2sp$)
- D) ($2sp^2$, $2sp^3$)
- E) ($2sp$, $1s$)

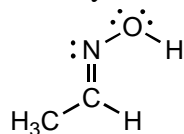
Ans: C

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

94. Identify the atomic orbital the lone pair electrons on the O atom are contained in:



- A) $2sp^2$
- B) $2sp^3$
- C) $2sp$
- D) $2s$
- E) $2p$

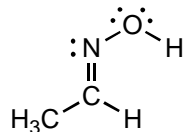
Ans: B

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

95. Identify the atomic orbital. The lone pair electrons on the N atom are contained in:



- A) $2sp^2$
- B) $2sp^3$
- C) $2sp$
- D) $2s$
- E) $2p$

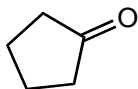
Ans: A

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

96. What is the hybridization of the O atom in the following molecule?



- A) sp^3
- B) sp^2
- C) sp
- D) s
- E) p

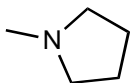
Ans: B

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

97. What is the hybridization of the N atom in the following molecule?



- A) sp^3
- B) sp^2
- C) sp
- D) s
- E) sp^4

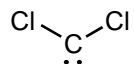
Ans: A

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

98. What is the hybridization of the C atom in the following molecule?



A) s

B) p

C) sp

D) sp²

E) sp³

Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

99. In which molecule is the central atom sp³ hybridized?

A) CH₄

B) NH₃

C) H₂O

D) All of these

E) None of these

Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Medium

100. In which of the following would you expect the central atom to be sp³ hybridized (or approximately sp³ hybridized)?

A) BH₄⁻

B) NH₄⁺

C) CCl₄

D) CH₃⁻

E) All of these

Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

101. Based on VSEPR theory, which of the following would have a trigonal planar shape?

- A) $(\text{CH}_3)_3\text{N}$
- B) HCN
- C) NH_4^+
- D) CH_3^-
- E) CH_3^+

Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

102. VSEPR theory predicts an identical shape for all of the following, except:

- A) NH_3
- B) H_3O^+
- C) BH_3
- D) CH_3^-
- E) All have the same geometry.

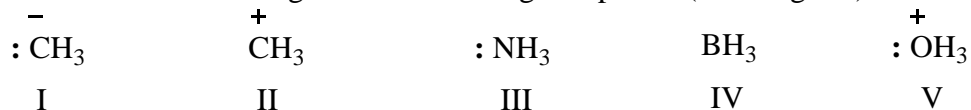
Ans: C

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

103. Which of the following would have a trigonal planar (or triangular) structure?



- A) I, II, and IV
- B) II and IV
- C) IV
- D) II, IV, and V
- E) All of these

Ans: B

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

104. Which of these structures would be a perfectly regular tetrahedron?

- A) CH_3Br
- B) CH_2Br_2
- C) CHBr_3
- D) CBr_4
- E) More than one of these

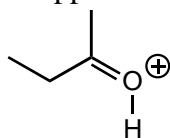
Ans: D

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

105. The bond angle for the C-C-O bonds in the following compound would be expected to be approximately:



- A) 60°
- B) 90°
- C) 105°
- D) 109°
- E) 120°

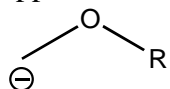
Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

106. The bond angle for the H-C-O bonds in the following molecule would be expected to be approximately:



- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

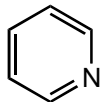
Ans: B

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Medium

107. What is the geometry of the N in the following molecule?



- A) tetrahedral
- B) trigonal pyramidal
- C) linear
- D) bent
- E) trigonal planar

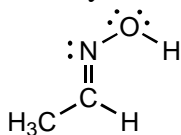
Ans: E

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Hard

108. Identify the atomic orbitals in the N-O sigma bond in the following oxime:



- A) ($2sp^2$, $2sp^2$)
- B) ($2sp^3$, $2sp^3$)
- C) ($2sp$, $2sp$)
- D) ($2sp^2$, $2sp^3$)
- E) ($2sp$, $1s$)

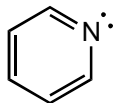
Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Hard

109. What is the hybridization of the N atom in the following molecule?



- A) s
- B) p
- C) sp
- D) sp^2
- E) sp^3

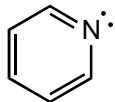
Ans: D

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Hard

110. Identify the atomic orbital. The lone pair electrons on the N atom are contained in:



- A) $2sp^2$
- B) $2sp^3$
- C) $2p$
- D) $2s$
- E) $2sp$

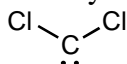
Ans: A

Topic: Atomic Orbitals, Hybridization

Section: 1.16

Difficulty Level: Hard

111. Identify the atomic orbital. The lone pair electrons on the C atom are contained in:



- A) $2sp^3$
- B) $2sp^2$
- C) $2sp$
- D) $2s$
- E) $2p$

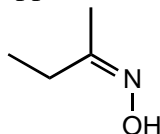
Ans: B

Topic: Lewis Structures, Molecular Geometry

Section: 1.16

Difficulty Level: Hard

112. The bond angle for the C-N-O bonds in the following molecule would be expected to be approximately:



- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

Ans: C

Topic: Atomic Orbitals, Bonding

Section: 1.4, 1.5, and 1.16

Difficulty Level: Medium

113. Which of these substances contain both covalent and ionic bonds?

- A) NH_4Cl
- B) H_2O_2
- C) CH_4
- D) HCN
- E) H_2S

Ans: A

Topic: Lewis Structures, Molecular Geometry

Section: 1.5 and 1.16

Difficulty Level: Easy

114. The bond angle for the C-C-H bonds in CH_3CN would be expected to be approximately:

- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

Ans: B

Topic: Lewis Structures, Molecular Geometry

Section: 1.5 and 1.16

Difficulty Level: Medium

115. The bond angle for the C-C-N bonds in CH_3CN would be expected to be approximately:

- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

Ans: E

Topic: Lewis Structures, Molecular Geometry

Section: 1.5 and 1.16

Difficulty Level: Medium

116. The bond angle for the C-P-C bonds in $(\text{C}_6\text{H}_5)_3\text{P}$ would be expected to be approximately:

- A) 60°
- B) 90°
- C) 109°
- D) 120°
- E) 180°

Ans: C

Topic: Molecular Geometry

Section: 1.5 and 1.16

Difficulty Level: Hard

117. Based on the VSEPR theory, which of the following would have a tetrahedral arrangement of electrons around the central atom?

- A) BH_3
- B) NO_2^-
- C) SiH_4
- D) CO_3^{2-}
- E) SO_3

Ans: C

Topic: Molecular Geometry

Section: 1.5 and 1.16

Difficulty Level: Hard

118. What would be the spatial arrangement of the atoms of the ozone molecule (O_3)?

- A) Linear
- B) Angular
- C) Trigonal planar
- D) Trigonal pyramidal
- E) Tetrahedral

Ans: B

Topic: Atomic Orbitals, Hybridization

Section: 1.5 and 1.16

Difficulty Level: Hard

119. In which molecule(s) can the molecular geometry be attributed to an sp^2 hybridized central atom?

- A) PBr_3
- B) CH_4
- C) $CHCl_3$
- D) HNO_2
- E) None of the above has an sp^2 hybridized central atom.

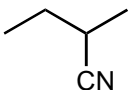
Ans: D

Topic: Lewis Structures, Molecular Geometry

Section: 1.5 and 1.16

Difficulty Level: Hard

120. What is the geometry of the N in the following molecule?



- A) tetrahedral
- B) trigonal pyramidal
- C) linear
- D) bent
- E) trigonal planar

Ans: C

Topic: Lewis Structures, Molecular Geometry

Section: 1.5, 1.6, and 1.16

Difficulty Level: Medium

121. Which molecule would be linear? (In each case you should write a Lewis structure before deciding.)

- A) SO_2
- B) HCN
- C) H_2O_2
- D) H_2S
- E) OF_2

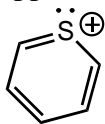
Ans: B

Topic: Lewis Structures, Molecular Geometry

Section: 1.5, 1.6 and 1.16

Difficulty Level: Hard

122. The bond angle for the C-S-C bonds in the following molecule would be expected to be approximately:



- A) 90°
- B) 109°
- C) 120°
- D) 145°
- E) 180°

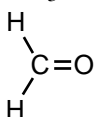
Ans: C

Topic: Atomic Orbitals, Hybridization

Section: 1.5, 1.14, and 1.16

Difficulty Level: Medium

123. Which molecule contains an *sp*-hybridized carbon?

- A) HCN
- B) $\text{CH}_2=\text{CH}_2$
- C) CH_3Cl
- D) 
- E) CH_3CH_3

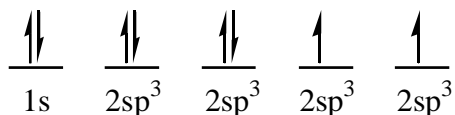
Ans: A

Topic: Atomic Orbitals, Electron Configuration, Hybridization

Section: 1.12 and 1.16

Difficulty Level: Easy

124. The following electron configuration represents:



- A) The ground state of nitrogen
- B) The ground state of oxygen
- C) The sp^3 hybridized state of carbon
- D) The excited state of oxygen
- E) None of the above correctly identifies the given electron configuration

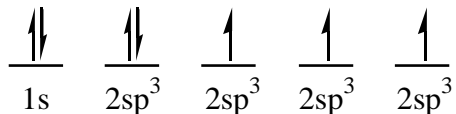
Ans: E

Topic: Atomic Orbitals, Hybridization

Section: 1.12 and 1.16

Difficulty Level: Medium

125. The following electron configuration represents _____



- A) the ground state of boron.
- B) the sp^3 hybridized state of carbon.
- C) the sp^3 hybridized state of nitrogen.
- D) the ground state of carbon.
- E) an excited state of carbon.

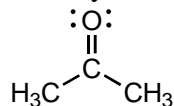
Ans: C

Topic: Atomic Orbitals, Hybridization

Section: 1.13 and 1.16

Difficulty Level: Medium

126. Identify the atomic orbitals in the C-O sigma bond in acetone.



- A) ($2sp^2$, $2sp^2$)
- B) ($2sp^3$, $2sp^3$)
- C) ($2sp$, $2sp$)
- D) ($2p$, $2p$)
- E) ($2sp$, $1s$)

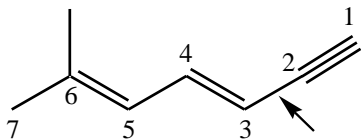
Ans: A

Topic: Atomic Orbitals, Hybridization, Bonding

Section: 1.13, 1.14, and 1.16

Difficulty Level: Easy

127. Identify the atomic orbitals involved in the C-2---C-3 sigma bond (indicated by an arrow) in the following molecule:



- A) sp^2, sp^2
B) sp^2, sp
C) sp^2, sp^3
D) sp^3, sp^2
E) sp, sp^2

Ans: E

SHORT ANSWER QUESTIONS

Topic: General

Section: Introduction

Difficulty Level: Easy

128. The modern definition of organic chemistry is _____.

Ans: the study of carbon compounds

Topic: General

Section: 1.1

Difficulty Level: Easy

129. Organic compounds were originally defined as compounds obtained from _____.

Ans: living sources/organisms

Topic: General

Section: 1.3A

Difficulty Level: Easy

130. Different compounds with the same molecular formula are referred to as _____.

Ans: isomers

Topic: General
Section: 1.3A
Difficulty Level: Easy

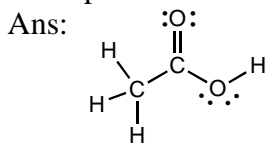
131. Constitutional isomers differ in the _____.
Ans: connectivity of their atoms

Topic: General
Section: 1.4B
Difficulty Level: Easy

132. The bond that results when two atoms share a pair of electrons is called a _____.
Ans: covalent bond

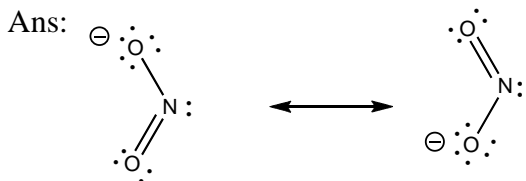
Topic: Lewis Structures
Section: 1.5
Difficulty Level: Medium

133. Draw the Lewis structure of acetic acid, $\text{CH}_3\text{CO}_2\text{H}$, clearly indicating all non-bonding pairs of electrons.



Topic: Lewis Structures
Section: 1.5 and 1.8
Difficulty Level: Medium

134. Draw the Lewis structure of the nitrite ion, NO_2^- , clearly indicating resonance contributors as well as non-bonding pairs of electrons and formal charges, as relevant.



Topic: Atomic orbitals
Section: 1.10
Difficulty Level: Easy

135. An orbital is defined as a region of space where the probability of _____ is high.
Ans: finding an electron

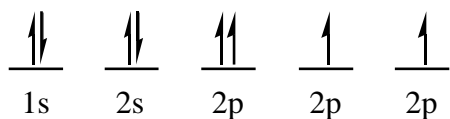
Topic: Atomic orbitals
Section: 1.10
Difficulty Level: Medium

136. Define an orbital.

Ans: A region of space where the probability of finding an electron is high.

Topic: Atomic orbitals
Section: 1.10A
Difficulty Level: Easy

137. There are three fundamental rules that we use in writing electronic configurations for atoms and molecules. The configuration shown below (for oxygen) violates one of these rules. Which one?



Ans: Pauli exclusion principle

Topic: Molecular orbitals
Section: 1.11
Difficulty Level: Easy

138. When atomic orbitals of opposite phase overlap a(n) _____ molecular orbital is formed.

Ans: antibonding

Topic: Molecular orbitals
Section: 1.11
Difficulty Level: Easy

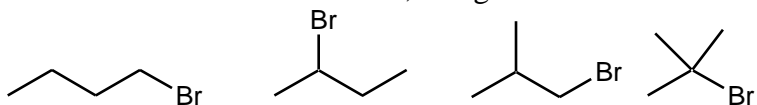
139. When atomic orbitals of the same phase overlap a(n) _____ molecular orbital is formed.

Ans: bonding

Topic: Isomers, Bond-Line Formulas
Section: 1.17C
Difficulty Level: Easy

140. Draw all the isomers of C_4H_9Br , using bond-line formulas.

Ans:



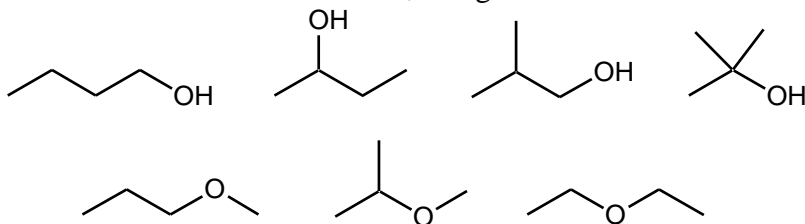
Topic: Isomers, Bond-Line Formulas

Section: 1.17C

Difficulty Level: Medium

141. Draw all the isomers of $C_4H_{10}O$, using bond-line formulas.

Ans:



Topic: Isomers, Bond-Line Formulas

Section: 1.17C

Difficulty Level: Medium

142. Draw all isomers of C_4H_8 , using bond-line formulas.

Ans:

