

CHAPTER 1 - Carbon and Its Compounds

1. Which of the following represents the ground state electron configuration for a O^{2-} ion?

- a. $1s^2 2s^2 2p^4$
- b. $1s^2 2s^2 2p^2$
- c. $1s^2 2s^2 2p^6$
- d. $2s^2 2p^4$

ANSWER: c

2. How many valence electrons does a nitrogen atom contain?

- a. 2
- b. 3
- c. 5
- d. 7

ANSWER: c

3. How many valence electrons does an O^{2-} ion contain?

- a. 2
- b. 6
- c. 8
- d. 10

ANSWER: c

4. What is the Lewis structure of a compound that has the formula of CCl_3 and contains 24 valence electrons?

- a. $\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{---}\ddot{\text{C}}\text{---}\ddot{\text{Cl}}\text{:} \\ | \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$
- b. $\begin{array}{c} \ominus \\ \text{:}\ddot{\text{Cl}}\text{---}\ddot{\text{C}}\text{---}\ddot{\text{Cl}}\text{:} \\ | \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$
- c. $\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{---}\ddot{\text{C}}\text{---}\ddot{\text{Cl}}\text{:} \\ | \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$
- d. $\begin{array}{c} \oplus \\ \text{:}\ddot{\text{Cl}}\text{---}\ddot{\text{C}}\text{---}\ddot{\text{Cl}}\text{:} \\ | \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$

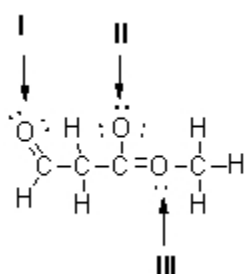
ANSWER: d

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5. How many bonded and non-bonded electrons does a molecule with no formal charges and the formula $C_2H_4O_2$ contain?
- 4 bonded, 4 non-bonded
 - 7 bonded, 4 non-bonded
 - 7 bonded, 5 non-bonded
 - 4 bonded, 7 non-bonded

ANSWER: b

Figure 1



6. Referring to Figure 1, what is the formal charge of the oxygen atom at **I**?
- +1
 - 0
 - 1
 - 2

ANSWER: b

7. Referring to Figure 1, what is the formal charge of the oxygen atom at **II**?
- +1
 - 0
 - 1
 - 2

ANSWER: c

8. Referring to Figure 1, what is the formal charge of the oxygen atom at **III**?
- +1
 - 0
 - 1
 - 2

ANSWER: a

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9. What best represents a C-H bond in CH_4 ?

- a. s-sp³ orbital overlap
- b. sp³-sp³ orbital overlap
- c. s-s orbital overlap
- d. p-p orbital overlap

ANSWER: a

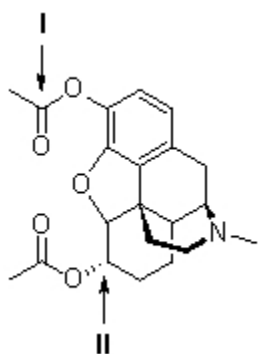
10. What best represents the C-C bond in C_2H_6 ?

- a. s-sp³ orbital overlap
- b. sp³-sp³ orbital overlap
- c. s-s orbital overlap
- d. p-p orbital overlap

ANSWER: b

Figure 2

The following questions refer to the structure of heroin (shown below).



11. Referring to Figure 2, what is the hybridization of the nitrogen atom?

- a. p
- b. sp
- c. sp²
- d. sp³

ANSWER: d

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12. Referring to Figure 2, what is the geometry of the carbon atom shown at **I**?

- a. bent
- b. trigonal planar
- c. tetrahedral
- d. trigonal pyramidal

ANSWER: b

13. Referring to Figure 2, what is the geometry of the carbon atom shown at **II**?

- a. bent
- b. trigonal planar
- c. tetrahedral
- d. trigonal pyramidal

ANSWER: c

14. Referring to Figure 2, what is the hybridization of the carbon atom at **I**?

- a. p
- b. sp
- c. sp^2
- d. sp^3

ANSWER: c

15. Referring to Figure 2, what is the hybridization of the carbon atom at **II**?

- a. p
- b. sp
- c. sp^2
- d. sp^3

ANSWER: d

16. Which element or ion has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^4$?

- a. S
- b. O
- c. Ar
- d. Si

ANSWER: a

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17. How many orientations exist for a s orbital?

- a. 1
- b. 2
- c. 3
- d. 4

ANSWER: a

18. How many orientations exist for a p orbital?

- a. 1
- b. 2
- c. 3
- d. 4

ANSWER: c

19. How many orientations exist for a sp^3 orbital?

- a. 1
- b. 2
- c. 3
- d. 4

ANSWER: d

20. How many orientations exist for an sp orbital?

- a. 1
- b. 2
- c. 3
- d. 4

ANSWER: b

21. What is the geometry around an sp^2 hybridized carbon?

- a. linear
- b. trigonal planar
- c. tetrahedral
- d. trigonal pyramidal

ANSWER: b

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22. What is the geometry around an sp hybridized carbon?

- a. linear
- b. trigonal planar
- c. tetrahedral
- d. trigonal pyramidal

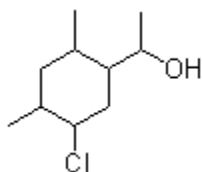
ANSWER: a

23. How many bonds does oxygen make while remaining neutral?

- a. 1
- b. 2
- c. 3
- d. 4

ANSWER: b

24. How many hydrogens does the following line structure contain?



- a. 1
- b. 10
- c. 19
- d. 26

ANSWER: c

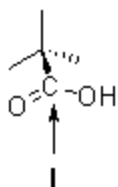
25. Which of the following best describes a σ^* orbital?

- a. It is a bonding orbital with zero nodes.
- b. It is an anti-bonding orbital with zero nodes.
- c. It is a bonding orbital with one node.
- d. It is an anti-bonding orbital with one node.

ANSWER: d

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26. What can be said about the carbon atom at **I**?



- It is sp^2 hybridized and pointed out of the page.
- It is sp^2 hybridized and pointed into the page.
- It is sp^3 hybridized and pointed out of the page.
- It is sp^3 hybridized and pointed into the page.

ANSWER: a

27. Which of the following molecules is represented in condensed structure?

-
- $$\begin{array}{ccccccc}
 & H & H & O & H & & \\
 & | & | & || & | & & \\
 H & -C & -C & -C & -C & -H \\
 & | & | & & | & & \\
 & H & H & & H & &
 \end{array}$$
- $CH_3CH_2COCH_3$
- $$\begin{array}{ccccccc}
 & H & H & O & H & & \\
 & | & | & || & | & & \\
 H & -C & -C & -C & -C & -H \\
 & | & | & & | & & \\
 & H & H & & H & &
 \end{array}$$

ANSWER: c

28. What best describes a wedged bond?

- It looks like \vdots and represents going into the page.
- It looks like \vdots and represents going out of the page.
- It looks like \uparrow and represents going into the page.
- It looks like \uparrow and represents going out of the page.

ANSWER: d

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29. What best represents the hydroxyl group in the molecule shown below?



- It is sp hybridized and pointed out of the page.
- It is sp hybridized and pointed into the page.
- It is sp^3 hybridized and pointed out of the page.
- It is sp^3 hybridized and pointed into the page.

ANSWER: c

30. Which of the following best describes a δ orbital?

- It is a bonding orbital with zero nodes.
- It is an anti-bonding orbital with zero nodes.
- It is a bonding orbital with one node.
- It is an anti-bonding orbital with one node.

ANSWER: c

31. What are the orbital angles around an sp^2 hybridized atom?

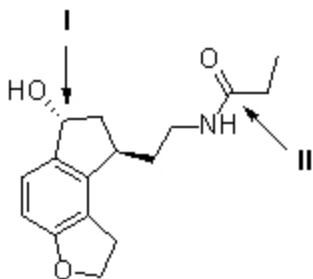
- 180°
- 120°
- 109.5°
- 90°

ANSWER: b

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Figure 3

The following questions refer to the molecule drawn below.



32. Referring to Figure 3, how many hydrogen atoms are contained in the molecule shown?

- a. 16
- b. 19
- c. 21
- d. 26

ANSWER: c

33. Referring to Figure 3, how many sp^2 atoms are contained in the molecule shown?

- a. 6
- b. 7
- c. 8
- d. 9

ANSWER: d

34. Referring to Figure 3, how many sp^3 atoms are contained in the molecule shown?

- a. 9
- b. 10
- c. 11
- d. 12

ANSWER: c

35. Referring to Figure 3, what is the hybridization of the carbon atom at **I**?

- a. s
- b. sp
- c. sp^2
- d. sp^3

ANSWER: d

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36. Referring to Figure 3, what best represents the hydroxyl group?

- a. It is sp hybridized and pointed out of the page.
- b. It is sp hybridized and pointed into the page.
- c. It is sp^3 hybridized and pointed out of the page.
- d. It is sp^3 hybridized and pointed into the page.

ANSWER: d

37. Referring to Figure 3, what is the orbital geometry of the carbon atom at **II**?

- a. trigonal planar
- b. trigonal pyramidal
- c. tetrahedral
- d. trigonal bipyramidal

ANSWER: b

38. Referring to Figure 3, what is the hybridization of the carbon atom at **II**?

- a. s
- b. sp
- c. sp^2
- d. sp^3

ANSWER: c

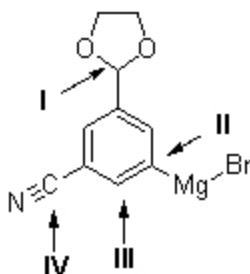
39. Referring to Figure 3, what is the orbital geometry of the carbon atom at **I**?

- a. trigonal planar
- b. trigonal pyramidal
- c. tetrahedral
- d. trigonal bipyramidal

ANSWER: c

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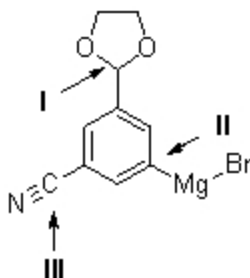
40. Which of the labelled carbons in the molecule shown below is the most electron rich?



- a. **I**
- b. **II**
- c. **III**
- d. **IV**

ANSWER: b

41. Which of the labelled carbons in the molecule shown below is the most electron rich and which is the most electron deficient?



- a. **I** is the most electron rich; **II** is the most electron deficient.
- b. **II** is the most electron rich; **I** is the most electron deficient.
- c. **I** is the most electron rich; **III** is the most electron deficient.
- d. **III** is the most electron rich; **I** is the most electron deficient.

ANSWER: b

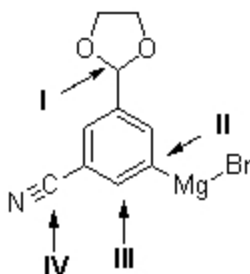
42. Which of the following structures is **NOT** breaking the octet rule?

- a. BF_3
- b. CCl_3^+
- c. H_3O^+
- d. PO_4^{3-}

ANSWER: c

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43. Which of the labelled carbons in the molecule shown below is the most electron deficient?



- a. **I**
- b. **II**
- c. **III**
- d. **IV**

ANSWER: a

44. sp^3 hybridization is the merging of an s orbital with two p orbitals.

- a. True
- b. False

ANSWER: False

45. Electrons in σ bonds can be delocalized.

- a. True
- b. False

ANSWER: False

46. Electronegativity is used to determine the polarity of a bond.

- a. True
- b. False

ANSWER: True

47. A carbanion contains a carbon atom with a formal negative charge.

- a. True
- b. False

ANSWER: True

48. Carbocations break the octet rule.

- a. True
- b. False

ANSWER: True

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49. In a O-H bond, the electron density is skewed towards the hydrogen atom.

- a. True
- b. False

ANSWER: False

50. A carbon atom with two δ bonds and two σ bonds is sp^2 hybridized.

- a. True
- b. False

ANSWER: False

51. Resonance structures contain delocalized electrons.

- a. True
- b. False

ANSWER: True

52. Anti-bonding orbitals are lower in energy than bonding orbitals.

- a. True
- b. False

ANSWER: False

53. σ^* represents an anti-bonding molecular orbital.

- a. True
- b. False

ANSWER: True

54. According to molecular orbital theory, all bonds contain a bonding and an anti-bonding orbital.

- a. True
- b. False

ANSWER: True

55. A σ molecular orbital contains out-of-phase overlap of atomic orbitals.

- a. True
- b. False

ANSWER: False

56. To form a σ bond, two atomic orbitals overlap to form a single molecular orbital.

- a. True
- b. False

ANSWER: False

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57. Only filled molecular orbitals contribute to bonding.

- a. True
- b. False

ANSWER: True

58. An sp^2 hybridized atom has a trigonal pyramidal geometry.

- a. True
- b. False

ANSWER: False

59. An sp^3 hybridized atom has a tetrahedral geometry.

- a. True
- b. False

ANSWER: True

60. The resonance hybrid is the most stable resonance form of a compound.

- a. True
- b. False

ANSWER: False

61. Resonance requires atoms with neighbouring aligned p orbitals.

- a. True
- b. False

ANSWER: True

62. Hybridized orbitals are capable of resonance.

- a. True
- b. False

ANSWER: False

63. Triple bonds are not capable of contributing to resonance.

- a. True
- b. False

ANSWER: False

64. A triple bond contains three δ bonds.

- a. True
- b. False

ANSWER: False

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65. Empty p orbitals are incapable of contributing to resonance structures.

- a. True
- b. False

ANSWER: False

66. The two δ bonds in an triple bond are 180° from each other.

- a. True
- b. False

ANSWER: False

67. Only carbon atoms can hybridize.

- a. True
- b. False

ANSWER: False

68. Anti-bonding orbitals involve out of plane overlap of atomic orbitals

- a. True
- b. False

ANSWER: True

69. An sp^2 hybridized carbon has an orbital geometry of _____.

ANSWER: trigonal planar

70. An sp hybridized carbon has an orbital geometry of _____.

ANSWER: linear

71. Electrons shared among atoms are said to be _____.

ANSWER: delocalized

72. Overlap of p orbitals is known as a _____ bond.

ANSWER: δ

73. A carbocation with three σ bonds is _____ hybridized.

ANSWER: sp^2

74. A carbocation with three σ bonds has a _____ geometry.

ANSWER: trigonal planar

75. A carbon atom with two δ bonds and two σ bonds is _____ hybridized.

ANSWER: sp

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76. The combined form of all resonance structures is referred to as the _____.

ANSWER: resonance hybrid

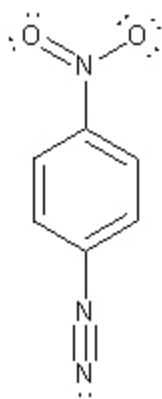
77. An sp hybridized atom has a _____ angle between each electron group.

ANSWER: 180°

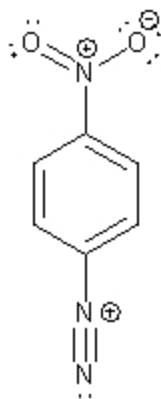
78. A Nitrogen atom with four σ bonds has a _____ formal charge.

ANSWER: +1

79. Assign non-zero formal charges to the following molecule.

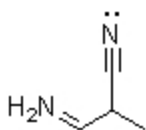


ANSWER: The charges are as follows:

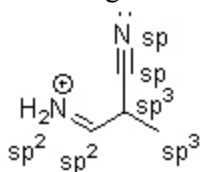


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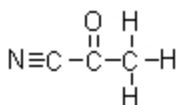
80. Assign non-zero formal charges and the hybridization to all atoms that are not hydrogen in the following molecule.



ANSWER: The charges and hybridizations are as follows:



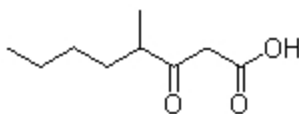
81. Assign the electron pair geometry and hybridization around each non-hydrogen atom in the following molecule, shown below.



ANSWER: From left to right
 Nitrogen-Linear, sp
 Carbon – Linear, sp
 Carbon – Trigonal planar, sp^2
 Oxygen – Trigonal planar sp^2
 Carbon – tetrahedral, sp^3

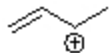
82. Draw the following molecule in zig-zag format: $\text{CH}_3(\text{CH}_2)_3\text{CH}(\text{CH}_3)\text{COCH}_2\text{COOH}$

ANSWER: The structure is as follows



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83. Identify the electron pair geometry and hybridization of every carbon atom in the following structure. Draw a resonance structure and the resonance hybrid of the following structure.



ANSWER: From left to right:

Carbon – Trigonal planar, sp^2

Carbon – Trigonal planar sp^2

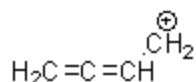
Carbon – Trigonal planar sp^2

Carbon – tetrahedral, sp^3

Resonance structure =

Resonance hybrid =

84. How many atoms share delocalized orbitals with the positively charged carbon, shown below. Explain your answer.



ANSWER: In order for delocalization to occur, neighbouring atoms must contain p orbitals that are aligned with each other. All four carbon atoms contain p orbitals. However, only the three right-most carbon p orbitals are in line with each other. The left-most σ bond is 90° out of plane with the carbocation p orbital.

