Chapter 1

Multiple Choice Questions:

Topic: General
Section: Intro
Difficulty Level: Easy

1. Chemical reactions occur as a result of:
   A) Attraction between opposite charges
   B) Nucleus–Nucleus interactions
   C) Motion of electrons
   D) Like atoms interacting
   E) Combining two chemicals
   Ans: C

Topic: General
Section: 1.1
Difficulty Level: Easy

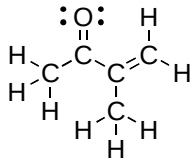
2. Credit for the first synthesis of an organic compound from an inorganic precursor is generally ascribed to:
   A) Berzelius
   B) Arrhenius
   C) Kekulé
   D) Wöhler
   E) Lewis
   Ans: D

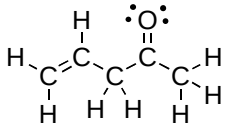
Topic: General
Section: 1.1
Difficulty Level: Easy

3. What was long thought to be the difference between inorganic and organic compounds?
   A) The number of atoms
   B) The synthesis of organic compounds required a vital force
   C) The molecular weight
   D) Inorganic compounds exhibited a strong nuclear force
   E) Inorganic compounds were composed exclusively of transition metals
   Ans: B

Topic: Isomerism
Section: 1.2
Difficulty Level: Easy

4. The following molecules are related in what manner?





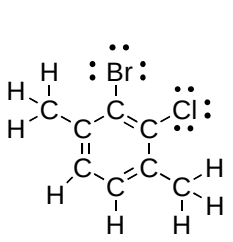
A) They are isotopes
B) They are constitutional isomers
C) They are the same structure
D) They are composed of different elements
E) There is no relationship
Ans: B

Topic: Isomerism
Section: 1.2
Difficulty Level: Easy

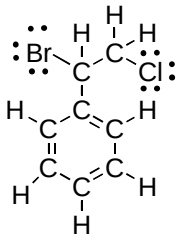
5. Constitutional isomers may *not* differ in what aspects?
A) Physical properties
B) Atomic connectivity
C) Molecular formula
D) Name
E) Constitution
Ans: C

Topic: Isomerism
Section: 1.2
Difficulty Level: Easy

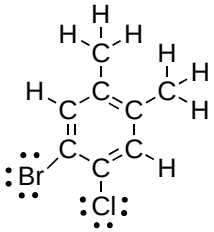
6. Which of the following structures represent compounds that are constitutional isomers?



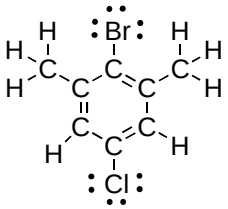
I



II



III



IV

A) I, II
B) III, IV
C) I, II, III
D) II, III, IV
E) All of the compounds are constitutional isomers
Ans: E

Topic: Bonding type
Section: 1.2
Difficulty Level: Easy

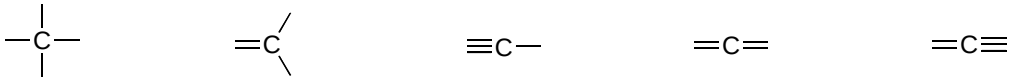
7. Carbon generally forms four bonds and is considered:
A) Tetravalent
B) Divalent
C) Trivalent
D) Monovalent
E) Qudravalent
Ans: A

Topic: Bonding type
Section: 1.2
Difficulty Level: Easy

8. A polar covalent bond is found in which of these compounds?
   A) H_2O
   B) F_2
   C) NaCl
   D) H_2
   E) N_2
   Ans: A

Topic: Bonding type
Section: 1.2
Difficulty Level: Easy

9. Which of the following bonding patterns of carbon is not allowed in the formation of an organic compound?

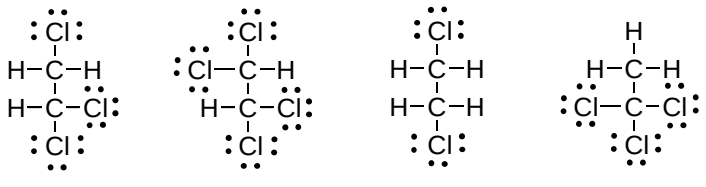


I II III IV V

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

Topic: Isomerism
Section: 1.2
Difficulty Level: Moderate

10. Which of the following molecules would be considered constitutional isomers?



I II III IV

   A) I, II
   B) III, IV
   C) II, III
   D) I, IV
   E) All of the compounds are constitutional isomers
   Ans: D

Topic: Bonding type, Lewis structures
Section: 1.2, 1.3
Difficulty Level: Moderate

11. Considering atoms with no formal charge, which statement best describes the valence of carbon, nitrogen, and oxygen?
    A) Carbon: two bonds, zero lone pairs; nitrogen: three bonds, two lone pairs
    B) Oxygen: two bonds, two lone pairs; nitrogen: three bonds, one lone pair
    C) Carbon: three bonds, one lone pair; oxygen: two bonds, two lone pairs
    D) Carbon: four bonds, zero lone pairs; nitrogen: two bonds, two lone pairs
    E) Oxygen: three bonds, one lone pair; nitrogen: two bonds, two lone pairs
    Ans: B

Topic: General
Section: 1.2
Difficulty Level: Moderate

12. The theory of matter's conceptual foundation involved contributions from:
    A) Friedrich Wöhler
    B) August Kekulé
    C) Archibald Scott Couper and Alexander M. Butlerov
    D) A and C
    E) B and C
    Ans E

Topic: Covalent bonding
Section: 1.3
Difficulty Level: Easy

13. What force is *not* taken into account in the formation of a covalent bond?
    A) Repulsion between two positively charged nuclei
    B) Repulsion between electron clouds on individual atoms
    C) Force of attraction between positively charged nuclei and electrons
    D) Repulsion of electrons by neutrons
    E) All forces listed are involved in forming a covalent bond
    Ans: D

Topic: Lewis structures
Section: 1.3
Difficulty Level: Easy

14. What is the correct Lewis dot structure for S?

A) 

B) 

C) 

D) 

E) 

Ans: C

Topic: Lewis structures
Section: 1.3
Difficulty Level: Easy

15. Which is the correct Lewis dot structure for carbon?

A) 

B) 

C) 

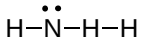
D) 

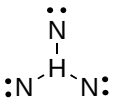
E) 

Ans: B

Topic: Lewis structures
Section: 1.3
Difficulty Level: Moderate

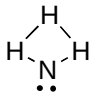
16. Which of the following represents the best Lewis structure for ammonia, NH_3?

A) 

B) 

C) 

D) 

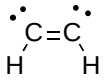
E) 

Ans: D

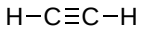
Topic: Lewis structures
Section: 1.3
Difficulty Level: Moderate

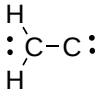
17. For a molecule with the formula C_2H_2, which of the structures below is most likely?

A) 

B) 

C) 

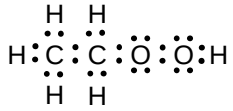
D) 

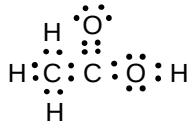
E) 

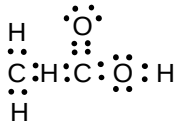
Ans: D

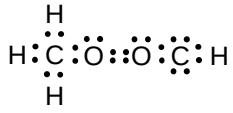
Topic: Lewis structures
Section: 1.3
Difficulty Level: Moderate

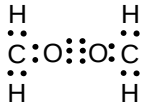
18. Which of the following is the most likely Lewis structure for CH_3CO_2H?

A) 

B) 

C) 

D) 

E) 

Ans: B

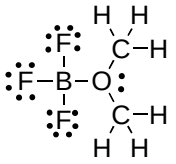
Topic: Lewis structures
Section: 1.3
Difficulty Level: Difficult

19. 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: Formal charges
Section: 1.4
Difficulty Level: Easy

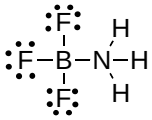
20. For the following molecule, indicate the correct formal charge on boron and oxygen respectively.



A) B = +1; O = +1
B) B = –1; O = –1
C) B = +1; O = –1
D) B = –1; O = +1
E) None of the choices are correct.
Ans: D

Topic: Formal charges
Section: 1.4
Difficulty Level: Easy

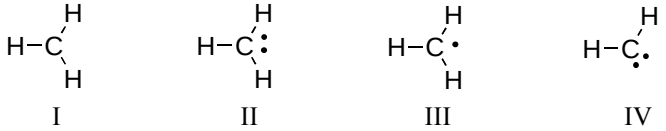
21. The respective formal charges of boron and nitrogen for the structure below are:



A) B = –1; N = –1
B) B = –1; N = +1
C) B = +1; N = –1
D) B = +1; N = +1
E) B = –1; N = 0
Ans: B

Topic: Formal charges
Section: 1.4
Difficulty Level: Easy

22. Which of the following species have a zero formal charge on the carbon atom?

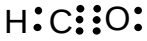


I II III IV

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

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

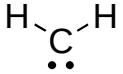
23. What is the formal charge on oxygen in the following structure?



A) +2
B) +1
C) 0
D) –1
E) –2
Ans: B

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

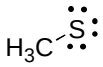
24. What is the formal charge on carbon in the following structure?

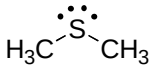


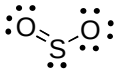
A) +2
B) +1
C) 0
D) –1
E) –2
Ans: C

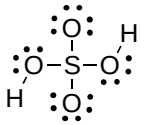
Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

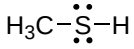
25. Which of the following molecules or ions has sulfur with a formal charge of –1? (Charges on ions have been omitted.)

A) 

B) 

C) 

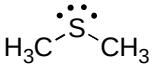
D) 

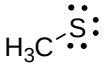
E) 

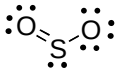
Ans: A

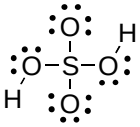
Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

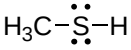
26. In which structure(s) below does sulfur have a formal charge of +1?


I


II


III

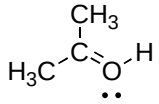

IV


V

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

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

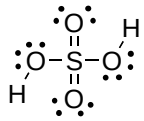
27. What is the formal charge on oxygen in the following structure?



A) +2
B) +1
C) 0
D) –1
E) –2
Ans: B

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

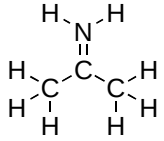
28. The formal charge on sulfur in this Lewis structure of sulfuric acid is:



A) 0
B) –1
C) +1
D) –2
E) +2
Ans: A

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

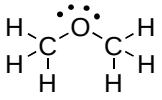
29. What is the formal charge of the nitrogen atom in the following compound?



A) +2
B) +1
C) 0
D) –1
E) –2
Ans: B

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

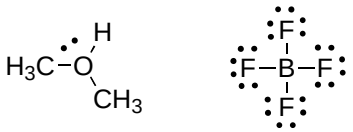
30. The formal charge on oxygen in dimethyl ether, CH_3OCH_3, is:

CH_3OCH_3 = 

A) +2
B) +1
C) 0
D) –1
E) –2
Ans: C

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Easy

31. The respective formal charges of the central atom for the following molecules are:



A) 0 and –1
B) 0 and +1
C) –1 and –1
D) –1 and +1
E) +1 and –1
Ans: E

Topic: Formal charge, bonding type
Section: 1.4, 1.9, 1.2
Difficulty Level: Easy

32. The bonding pattern of nitrogen with a formal charge of +1 could be described as:
A) One lone pair of electrons and three bonds
B) Two lone pairs of electrons and two bonds
C) Three lone pairs of electrons and one bond
D) Zero lone pairs of electrons and three bonds
E) Zero lone pairs of electrons and four bonds
Ans: E

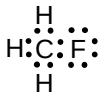
Topic: Formal charge, bonding type
Section: 1.4, 1.2
Difficulty Level: Moderate

33. In ammonium, nitrogen has a valence of 4, and zero nonbonding electrons. What is the correct formal charge of nitrogen with 4 covalent bonds?
A) –2
B) –1
C) 0
D) +1
E) +2
Ans: D

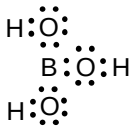
Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Moderate

34. Which Lewis structure below has a formal charge on at least one atom?

A) 

B) 

C) 

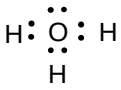
D) 

E) None of these structures have a formal charge

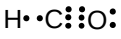
Ans: A

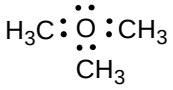
Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Moderate

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


I


II

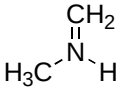

III

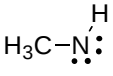

IV

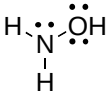
A) I only
B) II only
C) I and III
D) I and IV
E) I, III, and IV
Ans: E

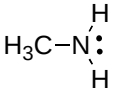
Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Moderate

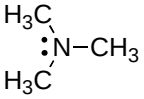
36. Which of the following structures is an ion with a single negative charge?

A) 

B) 

C) 

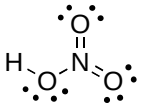
D) 

E) 

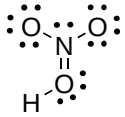
Ans: B

Topic: Formal charges, Lewis structures
Section: 1.4, 1.3
Difficulty Level: Moderate

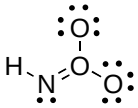
37. Which of the following molecules, with any formal charges omitted, would be considered the most likely Lewis structure for nitric acid, HNO_3?



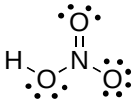
I



II



III



IV

A) I
B) II
C) III
D) IV
E) None of the structures represent a Lewis structure of HNO_3
Ans: D

Topic: Formal charge, bonding type
Section: 1.4, 1.9, 1.2
Difficulty Level: Moderate

38. The bonding pattern of oxygen with a formal charge of –1 could be described as:
    A) One lone pair of electrons and three single bonds
    B) Two lone pairs of electrons and two single bonds
    C) Three lone pairs of electrons, and one single bond
    D) One lone pair of electrons, one single, and one double bond
    E) Zero lone pairs, and two single and one double bond
    Ans: C

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

39. Select the *least* electronegative element from the list below:
    A) B
    B) C
    C) N
    D) O
    E) F
    Ans: A

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

40. Select the *most* electronegative element from the list below:
    A) O
    B) N
    C) C
    D) B
    E) H
    Ans: A

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

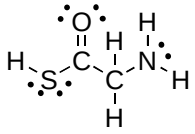
41. Select the *least* electronegative element from the list below:
    A) P
    B) N
    C) Mg
    D) Si
    E) K
    Ans: E

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

42. Select the *most* electronegative element from the list below:
    A) N
    B) P
    C) O
    D) S
    E) F
    Ans: E

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

43. Which atom is most electronegative in the compound below?



    A) C
    B) H
    C) O
    D) N
    E) S
    Ans: C

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

44. What is the correct order of *increasing* electronegativity for Rb, F, and O?
    A) Rb < F < O
    B) Rb < O < F
    C) O < F < Rb
    D) F < Rb < O
    E) The order cannot be determined
    Ans: B

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

45. Select the series of atoms that is correctly arranged in order of *increasing* electronegativity.
    A) C < N < B < Br
    B) P < N < As < F
    C) Li < B < N < F
    D) Cl < Cs < C < Co
    E) Be < B < Ba < Br
    Ans: C

Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

46. The electronegativity of elements on the periodic table tends to increase in what manner?
    A) From left to right, top to bottom
    B) From right to left, bottom to top
    C) From left to right, bottom to top
    D) From right to left, top to bottom
    E) All the atoms have the same electronegativity
    Ans: C

Topic: Bonding, types
Section: 1.5
Difficulty Level: Easy

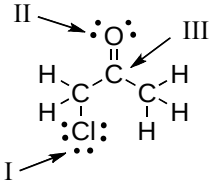
47. The Cl–Cl bond of chlorine is best described how?
    A) Nonpolar covalent
    B) Polar covalent
    C) Ionic
    D) Coordinate covalent
    E) Bonds do not form between chlorine atoms
    Ans: A

Topic: Bond polarity
Section: 1.5
Difficulty Level: Easy

48. The correct depiction of induction for a C–F bond is:
    A) 
    B) 
    C) 
    D) 
    E) 
    Ans: B

Topic: Bond polarity
Section: 1.5
Difficulty Level: Easy

49. Select the correct sequence identifying the partial charges for atoms in the following molecule:

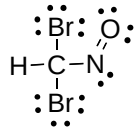


    A) I = δ+; II = δ+; III = δ+
    B) I = δ–; II = δ–; III = δ–
    C) I = δ+; II = δ+; III = δ–
    D) I = δ–; II = δ–; III = δ+
    E) I = δ+; II = δ–; III = δ+
    Ans: D

Topic: Bond polarity

Section: 1.5
Difficulty Level: Moderate

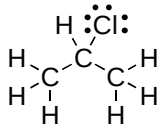
50. The atom with the largest δ+ in the following molecule is



A) H
B) C
C) Br
D) N
E) O
Ans: B

Topic: Bond polarity
Section: 1.5
Difficulty Level: Moderate

51. Which of the following statements best describes the carbon-chlorine bond of the molecule below?



A) nonpolar; no dipole
B) polar; δ+ at carbon and δ– at chlorine
C) polar; δ– at carbon and δ+ at chlorine
D) ionic
E) none of the above
Ans: B

Topic: Bond polarity, electronegativity
Section: 1.5
Difficulty Level: Moderate

52. Based on electronegativity, which of the compounds below has a partial negative (δ–) charge on the bonded hydrogen atom?

A) BH_3
B) CH_4
C) NH_3
D) H_2O
E) CH_4
Ans: A

Topic: Electron configuration

Section: 1.6
Difficulty Level: Easy

53. How is the full electron configuration of phosphorous represented?
    A) $1s^2\ 2s^2\ 2p^6\ 3s^1\ 3p^4$
    B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
    C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
    D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
    E) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
    Ans: C

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

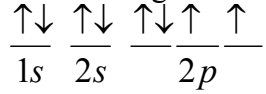
54. What is the electronic configuration for the nitride ion, N^{3-}?
    A) $1s^2\ 2s^2\ 2p^0$
    B) $1s^2\ 2s^2\ 2p^2$
    C) $1s^2\ 2s^2 2p^3$
    D) $1s^2\ 2s^2 2p^4$
    E) $1s^2\ 2s^2\ 2p^6$
    Ans: E

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

55. The atomic number of nitrogen is 7. The correct ground-state electronic configuration of nitrogen is:
    A) $1s^2\ 2s^1\ 2p^4$
    B) $1s^2\ 2p^5$
    C) $1s^2\ 2s^2\ 2p^3$
    D) $2s^2\ 2p^5$
    E) $1s^2\ 2s^2\ 3s^3$
    Ans: C

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

56. The following electron configuration represents which element?



A) Boron
B) Carbon
C) Nitrogen
D) Oxygen
E) Fluorine
Ans: D

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

57. How many distinct *p* orbitals exist in the second electron shell?
A) 2
B) 3
C) 4
D) 5
E) 6
Ans: B

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

58. Which of the following elements does this electronic configuration represent?
$1s^2\ 2s^2\ 2p^5$
A) F
B) C
C) N
D) Al
E) O
Ans: A

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

59. Which element has the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$?
    A) Oxygen
    B) Fluorine
    C) Sulfur
    D) Chlorine
    E) Bromine
    Ans: D

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

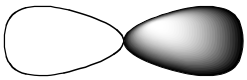
60. The electron configuration of a carbon atom has how many electrons unpaired?
    A) none
    B) one
    C) two
    D) three
    E) four
    Ans: C

Topic: Atomic orbitals
Section: 1.6
Difficulty Level: Easy

61. Orbitals that are equivalent in energy are referred to as:
    A) quantum
    B) antibonding
    C) bonding
    D) degenerate
    E) LUMO
    Ans: D

Topic: Atomic orbitals
Section: 1.6
Difficulty Level: Easy

62. The orbital below is given what letter designation?



A) *s*
B) *p*
C) *d*
D) *f*
E) *l*
Ans: B

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

63. The electrons of carbon are best described as found in which orbitals?
A) Three *s* electrons; Three *p* electrons
B) Two 1*s* electrons; Four 2*p* electrons
C) Two 1*s* electrons; Two 2s electrons; Two 2*p* electrons
D) Two 1*s* electrons; Two 2*s* electrons; Four 2*p* electrons
E) None of these choices are correct.
Ans: C

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

64. Which element in the second row of the periodic table has six valence electrons and a valence of two?
A) Boron
B) Carbon
C) Nitrogen
D) Oxygen
E) None have a valence of two
Ans: D

Topic: Electron configuration
Section: 1.6
Difficulty Level: Moderate

65. The ground state electron configuration of carbon is:
    A) $1s^2\,2s^2\,2p_x^{\,1}$
    B) $1s^2\,2s^2\,2p_x^{\,2}$
    C) $1s^2\,2s^2\,2p_x^{\,1}\,2p_y^{\,1}$
    D) $1s^2\,2s^2\,2p_x^{\,2}\,2p_y^{\,1}$
    E) $1s^2\,2s^1\,2p_x^{\,1}\,2p_y^{\,1}\,2p_z^{\,1}$
    Ans: C

Topic: Electron configuration
Section: 1.6
Difficulty Level: Moderate

66. Which principle states that each orbital may hold a maximum of 2 electrons with opposite spins?
    A) aufbau principle
    B) Pauli exclusion principle
    C) Hund's rule principle
    D) LeChâtelier principle
    E) uncertainty principle
    Ans: B

Topic: Electron configuration
Section: 1.6
Difficulty Level: Moderate

67. Which principle(s) or rule must be used to determine the correct electronic configuration for any atom 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
Section: 1.6
Difficulty Level: Hard

68. 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, bonding
Section: 1.7
Difficulty Level: Easy

69. *All* single bonds can be classified as:
    A) nonpolar covalent.
    B) polar covalent.
    C) ionic.
    D) σ bonds.
    E) π bonds.
    Ans: D

Topic: Atomic orbitals, bonding
Section: 1.7
Difficulty Level: Moderate

70. What is the result when waves interfere constructively?
    A) A wave with larger amplitude
    B) A wave with smaller amplitude
    C) Cancellation of both waves
    D) Formation of a node
    E) Destructive interference
    Ans: A

Topic: Atomic orbitals, bonding
Section: 1.7
Difficulty Level: Moderate

71. The electron density of what bonding type has spherical symmetry?
    A) σ
    B) π
    C) δ
    D) Covalent
    E) Ionic
    Ans: A

Topic: Molecular orbitals
Section: 1.8
Difficulty Level: Easy

72. In molecular orbital (MO) theory, the molecular orbital of highest energy that is occupied with an electron is referred to as:
    A) degenerate.
    B) the LCAO.
    C) the LUMO.
    D) the HOMO.
    E) antibonding.
    Ans D

Topic: Molecular orbitals
Section: 1.8
Difficulty Level: Moderate

73. The difference between valence bond theory and molecular orbital (MO) theory is:
    A) valence bond theory requires the linear combination of atomic orbitals.
    B) MO theory is more simplistic in its treatment of bonds.
    C) valence bond theory considers only individual atomic orbitals.
    D) A and B are correct
    E) B and C are correct
    Ans E

Topic: Molecular orbitals
Section: 1.8
Difficulty Level: Moderate

74. When the 1*s* 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: Molecular orbitals
Section: 1.8
Difficulty Level: Moderate

75. When the 1*s* 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: Molecular orbitals
Section: 1.8
Difficulty Level: Moderate

76. When the 1*s* 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: Molecular orbitals
Section: 1.8
Difficulty Level: Hard

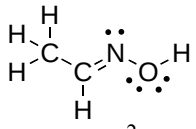
77. For a bond forming reaction involving donation of electrons between atoms, electron density is transferred into which molecular orbital of the accepting atom?
    A) *s* orbital
    B) *p* orbital
    C) *d* orbital
    D) HOMO
    E) LUMO
    Ans: E

Topic: Molecular orbitals
Section: 1.8
Difficulty Level: Hard

78. When two hydrogen 1*s* atomic orbitals of the same phase interact, which of the statements below is *incorrect*?
    A) A sigma bonding molecular orbital is formed.
    B) The bonding molecular orbital formed is lower in energy than a hydrogen 1*s* atomic orbital.
    C) The bonding molecular orbital formed has a node between the atoms.
    D) The bonding molecular orbital formed is cylindrically symmetric.
    E) A maximum of two electrons may occupy the bonding molecular orbital.
    Ans: C

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Easy

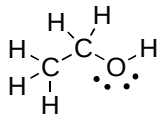
79. The nitrogen atom's lone pair of electrons are contained in what orbital type?



    A) sp^2
    B) sp^3
    C) *sp*
    D) *s*
    E) *p*
    Ans: A

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Easy

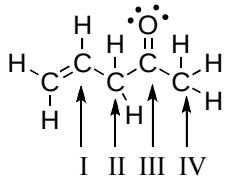
80. What is the hybridization of the oxygen atom in ethanol, the molecule shown below?



A) sp
B) sp^2
C) sp^3
D) p^3
E) d^2sp^3
Ans: C

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Easy

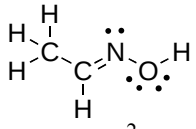
81. Which carbons in the following molecule are sp^2 hybridized?



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

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Easy

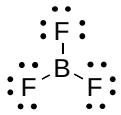
82. The lone pairs of electrons of the oxygen atom are located in which orbitals?



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

Topic: Atomic orbitals hybridization
Section: 1.9
Difficulty Level: Easy

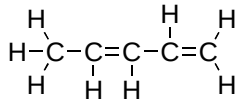
83. The hybridization of the B atom in the following molecule is?



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

Topic: Atomic orbital hybridization, bonding
Section: 1.9
Difficulty Level: Easy

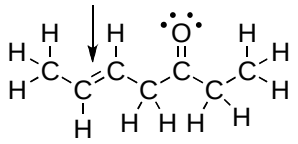
84. How many s–sp^2 bonds are in the following molecule?



A) 2
B) 3
C) 4
D) 5
E) 6
Ans: D

Topic: Atomic orbital hybridization, bonding
Section: 1.9
Difficulty Level: Easy

85. The σ carbon–carbon bond indicated by the arrow in the following molecule results from the overlap of which orbitals (in the order left to right)?



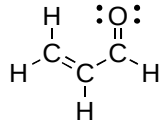
A) sp–sp^2
B) sp–sp^3
C) sp^2–sp^2
D) sp^2–sp^3
E) sp^3–sp^2
Ans: C

Topic: Atomic orbital hybridization, bonding
Section: 1.9
Difficulty Level: Easy

86. Identify the atomic orbitals in the C–C sigma (σ) bond in ethyne, H–C≡C–H.
A) (sp^2, sp^2)
B) (sp^3, sp^3)
C) (sp, sp)
D) (p, p)
E) (sp, s)
Ans: C

Topic: Atomic orbital hybridization, bonding type
Section: 1.9
Difficulty Level: Easy

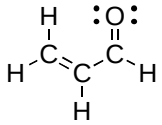
87. How many π bonds are present in the following molecule?



A) one
B) two
C) three
D) four
E) five
Ans: B
Topic: Atomic orbital hybridization, bonding type

Section: 1.9
Difficulty Level: Easy

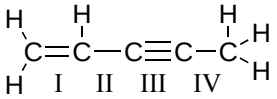
88. The σ bond that is part of the carbon–carbon double bond in the molecule below is formed from the overlap of which two types of hybridized orbitals?



A) *sp*–*sp*
B) sp^2–*sp*
C) sp^2–sp^2
D) sp^2–sp^3
E) sp^3–sp^3
Ans: C

Topic: Bond length
Section: 1.9
Difficulty Level: Easy

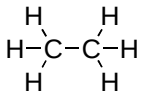
89. Which bond in the following molecule is the shortest?

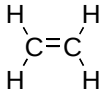


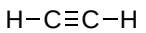
A) Bond I
B) Bond II
C) Bond III
D) Bond IV
E) Bonds I and III are the same length
Ans: C

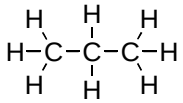
Topic: Atomic orbitals, bonding strength/bonding length
Section: 1.9
Difficulty Level: Easy

90. Which compound contains the shortest carbon–carbon bond?

A) 

B) 

C) 

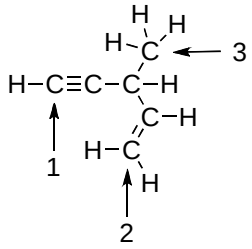
D) 

E) All carbon–carbon bonds are the same length.

Ans: C

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Moderate

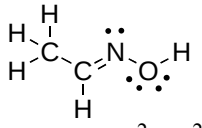
91. The correct hybridization for the numbered carbon atoms is given by which sequence?



A) sp^3, sp^2, sp
B) sp^2, sp, sp^2
C) sp, sp^2, sp^3
D) sp, sp^2, sp
E) sp^2, sp^3, sp^2
Ans: C

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Moderate

92. Identify the hybridized orbitals involved in formation of the C–N sigma (σ) bond in the following molecule known as an oxime:



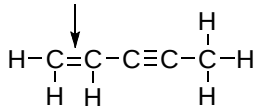
A) (sp^2, sp^2)
B) (sp^3, sp^3)
C) (sp, sp)
D) (sp^2, sp^3)
E) There is no sigma bond between C–N.
Ans: A

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Moderate

93. The hybridization of nitrogen in trimethylamine, $(CH_3)_3N$:, is best described as:
A) sp
B) sp^2
C) sp^3
D) p^3
E) d^2sp^3
Ans: C

Topic: Atomic orbital hybridization, bonding
Section: 1.9
Difficulty Level: Moderate

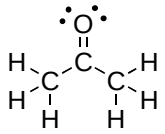
94. The bonds indicated by the arrow in the molecule below is formed from the overlap of which orbital(s)?



A) sp^3–sp^3
B) sp^2–sp^2
C) p–p
D) A and B are correct
E) B and C are correct
Ans: E

Topic: Atomic orbital hybridization, bonding type
Section: 1.9
Difficulty Level: Moderate

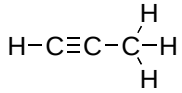
95. The best description of the orbitals used to form the C=O bond in acetone, the molecule shown below, is given by:



A) $\sigma = C_{sp^2} - O_{sp^2}$ and $\pi = C_{sp^2} - O_{sp^2}$
B) $\sigma = C_{sp^2} - O_{sp^2}$ and $\pi = C_{p} - O_{p}$
C) $\sigma = C_{sp^3} - O_{sp^2}$ and $\pi = C_{p} - O_{p}$
D) $\sigma = C_{p} - O_{p}$ and $\pi = C_{sp^2} - O_{sp^2}$
E) $\sigma = C_{sp} - O_{sp}$ and $\pi = C_{p} - O_{p}$
Ans: B

Topic: Atomic orbital hybridization, bonding type
Section: 1.9
Difficulty Level: Moderate

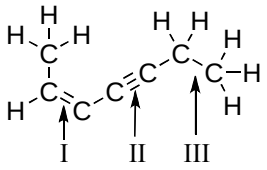
96. How many σ bonds occur between carbon atoms in the following molecule?



A) 1
B) 2
C) 3
D) 4
E) 5
Ans: B

Topic: Bonding strength, bond polarity
Section: 1.9, 1.5
Difficulty Level: Moderate

97. Which statement concerning the length of bonds indicated in the molecule below is correct?



A) II is the shortest and I is the longest
B) II is the shortest and III is the longest
C) III is the shortest and II is the longest
D) III is the shortest and I is the longest
E) I is the shortest and III is the longest
Ans: B

Topic: Atomic orbital hybridization, bonding type
Section: 1.9
Difficulty Level: Moderate

98. The H–C bond in the methyl cation, CH_3^+, is formed from the overlap of what orbitals?

A) sp^3–sp^3
B) sp^2–sp^3
C) s–p
D) s–sp^2
E) s–sp^3
Ans: D

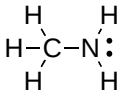
Topic: Atomic orbital hybridization, bonding type
Section: 1.9
Difficulty Level: Moderate

99. For the methyl anion, $:CH_3^-$, the lone pair of electrons reside in which hybridized orbital?

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

Topic: Atomic orbital hybridization, bonding type
Section: 1.9
Difficulty Level: Moderate

100. For the molecule below answer the following in order: The N–H bond is of what type and formed from the overlap of which orbital types?



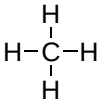
A) σ bond; $sp^2 - s$ orbital overlap
B) σ bond; $sp^3 - s$ orbital overlap
C) π bond; $sp^3 - s$ orbital overlap
D) π bond; $sp^2 - p$ orbital overlap
E) π bond; $p - p$ orbital overlap
Ans: B

Topic: Atomic orbital hybridization, Lewis structures
Section: 1.9, 1.3
Difficulty Level: Moderate

101. Which of the structures below contain an sp^2 hybridized carbon?

I

II



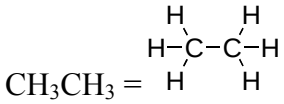
III

IV

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

Topic: Atomic orbital hybridization, bonding type, Lewis structures
Section: 1.9, 1.3
Difficulty Level: Moderate

102. Which of the following would be a correct description of the carbon–hydrogen bond in ethane, CH_3CH_3?

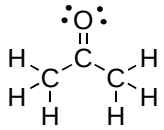


CH_3CH_3 =

A) highly polar
B) nonpolar
C) a pi (π) bond
D) a multiple bond
E) ionic
Ans: B

Topic: Atomic orbital hybridization, bonding type, Lewis structures
Section: 1.9, 1.3
Difficulty Level: Moderate

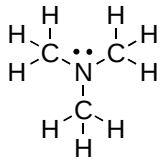
103. Identify the orbitals in the C–O sigma bond in acetone.



A) (sp^2, sp^2)
B) (sp^3, sp^3)
C) (sp, sp)
D) (p, p)
E) (sp, s)
Ans: A

Topic: Atomic orbital hybridization, molecular geometry, bonding angle
Section: 1.9
Difficulty Level: Moderate

104. The correct hybridization and bond angle of nitrogen in trimethylamine, the molecule shown below, is:



A) sp^2, bond angle greater than 109.5°
B) sp^2, bond angle less than 109.5°
C) sp^3, bond angle greater than 109.5°
D) sp^3, bond angle less than 109.5°
E) sp^3, bond angle exactly 109.5°
Ans: D

Topic: Bond length/bond strength
Section: 1.9
Difficulty Level: Moderate

105. Correctly compare the bond length and strength for the molecules below:

I II

A) The shortest and strongest bond is found in molecule I
B) The shortest and strongest bond is found in molecule II
C) The shortest and weakest bond is found in molecule I
D) The shortest and weakest bond is found in molecule II
E) The bonds are of identical length and strength
Ans: B

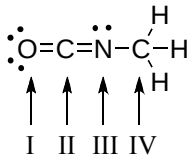
Topic: Bond strength/bond length, bond polarity
Section: 1.9, 1.5
Difficulty Level: Moderate

106. For the hydrogen halides, which is the correct sequence for a) the molecule with the weakest bond, b) the molecule with the shortest bond, and c) the molecule with the most polar bond.

A) HF HI HBr
B) HI HBr HCl
C) HBr HI HF
D) HI HBr HF
E) HCl HBr HI
Ans: D

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Hard

107. From left to right, indicate the hybridization of the indicated atoms in the following molecule:



A) I – sp ; II – sp^2 ; III – sp^3 ; IV – sp^2
B) I – sp^2 ; II – sp ; III – sp^2 ; IV – sp^3
C) I – sp^3 ; II – sp^2 ; III – sp ; IV – sp^2
D) I – sp^2 ; II – sp^3 ; III – sp^2 ; IV – sp
E) I – sp^2 ; II – sp^2 ; III – sp^2 ; IV – sp^3
Ans: B

Topic: Atomic orbital hybridization, bonding type, Lewis structures
Section: 1.9, 1.3
Difficulty Level: Hard

108. The carbon and oxygen atoms in carbon monoxide (CO) are connected by which type of bond(s)?

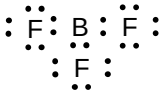
A) A sigma (σ) bond
B) Two sigma (σ) bonds
C) A pi (π) bond
D) Two pi (π) bonds
E) Both A and D
Ans: E

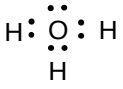
Topic: Molecular geometry
Section: 1.10
Difficulty Level: Easy

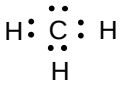
109. The molecular geometry of carbon tetrachloride, CCl_4, is best described as:
A) tetrahedron
B) square
C) cube
D) circle
E) sphere
Ans: A

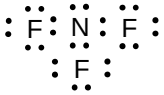
Topic: Molecular geometry, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Easy

110. Which of the structures below, with any formal charges omitted, would have a trigonal planar molecular geometry?


I


II


III


IV

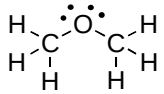
A) I
B) II
C) III
D) IV
E) I and IV
Ans: A

Topic: Molecular geometry, bonding angles
Section: 1.10
Difficulty Level: Easy

111. What bond angle is associated with a tetrahedral atom?
A) 120°
B) 109.5°
C) 180°
D) 90°
E) 45°
Ans: B

Topic: Molecular geometry, bonding angles, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Easy

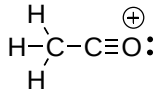
112. What is the approximate bond angle for the C–O–C bonds in the molecule below?



A) ~90°
B) ~109°
C) ~120°
D) ~145°
E) ~180°
Ans: B

Topic: Molecular geometry, bonding angles, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Easy

113. What is the expected bond angle for the C–C–O bonds in the molecule below?



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

Topic: Molecular geometry
Section: 1.10
Difficulty Level: Moderate

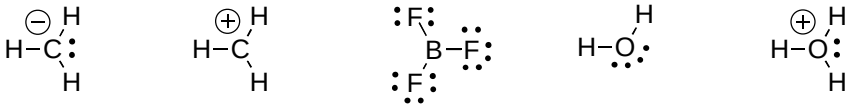
114. What shape is the shape of the molecule BF_3, with only three covalent bonds to, and no lone pairs of electrons on, the boron atom?
A) Trigonal pyramidal
B) Trigonal planar
C) Tetrahedral
D) Linear
E) Bent
Ans: B

Topic: Molecular Geometry
Section: 1.10
Difficulty Level: Moderate

115. The molecular geometry of water is best described as:
    A) Pyramidal
    B) Linear
    C) Bent
    D) Tetrahedral
    E) Square Planar
    Ans: C

Topic: Molecular geometry
Section: 1.10
Difficulty Level: Moderate

116. Of the molecules below, which are expected to have a trigonal planar molecular geometry?



I II III IV V

    A) I, II, and III
    B) II and III
    C) II and V
    D) III only
    E) All of the molecules are trigonal planar.
    Ans: B

Topic: Molecular geometry
Section: 1.10
Difficulty Level: Moderate

117. Which of the molecules below have a molecular geometry similar to a tetrahedron?

I II III IV V VI

    A) II, III, IV, V
    B) I, II, V, VI
    C) II, III
    D) IV, V
    E) II, III, VI
    Ans: B

Topic: Molecular geometry
Section: 1.10
Difficulty Level: Moderate

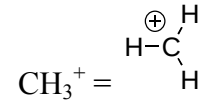
118. What shape does the methane molecule, CH_4, have?
    A) A triangular pyramid
    B) A square pyramid
    C) A square plane
    D) A tetrahedron
    E) Bent
    Ans: D

Topic: Molecular geometry, bonding angles, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Hard

119. What is the approximate bond angle around the carbon in formaldehyde, a molecule with the formula H_2CO?
    A) 60°
    B) 90°
    C) 109.5°
    D) 120°
    E) 180°
    Ans: D

Topic: Molecular geometry, bonding angles, atomic orbital hybridization
Section: 1.10, 1.9
Difficulty Level: Moderate

120. For the methyl cation, CH_3^+, the geometry, H–C–H bond angle, and hybridization of the carbon atom is best described as:



    A) trigonal planar, 120°, sp^2
    B) trigonal planar, 120°, sp^3
    C) trigonal planar, 109.5°, sp^2
    D) trigonal pyramidal, 120°, sp^2
    E) trigonal pyramidal, 109.5°, sp^2
    Ans: A

Topic: Molecular geometry, bonding angles, atomic orbital hybridization
Section: 1.10, 1.9
Difficulty Level: Moderate

121. For the methyl anion, $:CH_3^-$, the geometry, H–C–H bond angle, and hybridization of the carbon atom is best described as:

$:CH_3^-$ = 

A) trigonal planar, ~120°, sp^2
B) trigonal pyramidal, ~120°, sp^3
C) trigonal pyramidal, ~109.5°, sp^2
D) trigonal pyramidal, ~109.5°, sp^3
E) trigonal planar, ~109.5°, sp^3
Ans: D

Topic: Molecular geometry, bonding angles, atomic orbital hybridization
Section: 1.10, 1.9
Difficulty Level: Moderate

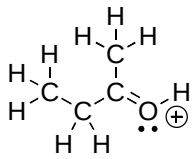
122. For methyl carbene, $:CH_2$, the geometry, H–C–H bond angle, and hybridization of the carbon atom is best described as:

$:CH_2$ = 

A) bent, ~120°, sp^2
B) bent, ~120°, sp^3
C) tetrahedral, ~109.5°, sp^2
D) tetrahedral, ~109.5°, sp^3
E) trigonal pyramidal, ~109.5°, sp^3
Ans: A

Topic: Molecular geometry, bonding angles, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Moderate

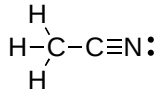
123. What is the expected bond angle for the C–C–O bonds in the molecule below?



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

Topic: Molecular geometry, bonding angles, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Moderate

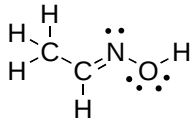
124. The approximate bond angles for the C–C–H bonds in the following molecule are:



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

Topic: Molecular geometry, bonding angles, Lewis structures
Section: 1.10, 1.3
Difficulty Level: Moderate

125. What is the geometry of nitrogen in the following molecule?



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

Topic: Molecular geometry, Lewis structures, atomic orbital hybridization
Section: 1.10, 1.3, 1.9
Difficulty Level: Hard

126. Which molecule has a non–linear shape (i.e., for which molecule are the nuclei *not* arranged in a straight line, and *without* a bond angle of 180°)?
A) CO_2
B) H_2O
C) HCl
D) HCN
E) C_2H_2
Ans: B

Topic: Molecular polarity, molecular dipole
Section: 1.11, 1.5
Difficulty Level: Easy

127. Which of the following molecules, with any formal charges omitted, would be expected to have a dipole moment?

I II III IV

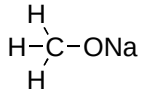
A) II and III
B) only II
C) only III
D) I, II, and III
E) II, III, IV
Ans: E

Topic: Ionic character, electronegativity
Section: 1.11, 1.5
Difficulty Level: Easy

128. 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) C and Br
F) Br and Cl
Ans: B

Topic: Electronegativity, bonding type, ionic character
Section: 1.11, 1.5
Difficulty Level: Easy

129. In the compound sodium methoxide ($NaOCH_3$), what type of bonding occurs?



$NaOCH_3$ =

A) ionic
B) polar covalent
C) nonpolar covalent
D) a mixture of ionic and covalent
E) hydrogen
Ans: D

Topic: Electronegativity, bonding type, ionic character
Section: 1.11, 1.5
Difficulty Level: Easy

130. 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: Electronegativity, bonding type, ionic character
Section: 1.11, 1.5, 1.3
Difficulty Level: Easy

131. Which of the following compounds are covalent compounds?
A) KF
B) CHF_3
C) NH_3
D) both A and B
E) both B and C
Ans: E

Topic: Electronegativity, bonding type, ionic character
Section: 1.11, 1.5, 1.3
Difficulty Level: Easy

132. Which of the following contain(s) polar covalent bonds?
A) NH_3
B) Na_2O
C) H_2
D) KF
E) both A and C
Ans A

Topic: Bond polarity, bond dipole
Section: 1.11, 1.5
Difficulty Level: Easy

133. Which of the following covalent bonds has the *largest* dipole moment?
A) C–C
B) C–H
C) C–O
D) H–N
E) H–F
Ans: E

Topic: Molecular polarity, molecular dipole, bond polarity
Section: 1.11, 1.5
Difficulty Level: Moderate

134. Which of the following molecules has the *smallest* dipole moment?
    A) Cl_2
    B) NH_3
    C) HF
    D) HCl
    E) HBr
    Ans: A

Topic: Intermolecular forces, bond polarity, molecular polarity
Section: 1.11, 1.5
Difficulty Level: Moderate

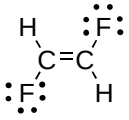
135. Which of the following statements best explains the observation that HF has the highest boiling point of all the hydrogen halides?
    A) The fluorine in HF is the smallest atom for all of the halogens
    B) Fluorine is the most electronegative of the atoms
    C) HF can participate in hydrogen bonding
    D) HF is very reactive and can react and dissolve glass
    E) HF is a weak acid, and doesn't completely dissociate
    Ans: C

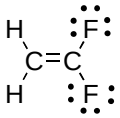
Topic: Molecular polarity, molecular dipole, bond polarity
Section: 1.11, 1.5
Difficulty Level: Moderate

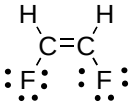
136. Select the molecule that *does not* exhibit a net dipole moment of zero?
    A) CBr_4
    B) CO_2
    C) CH_4
    D) H_2O
    E) C_2H_4
    Ans: D

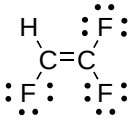
Topic: Molecular polarity, molecular dipole, bond polarity
Section: 1.11, 1.5
Difficulty Level: Moderate

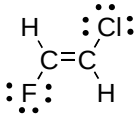
137. Which of the following molecules has a net dipole moment of zero?


I


II


III


IV


V

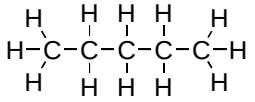
A) I
B) II
C) III
D) IV
E) V
Ans: A

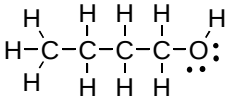
Topic: Molecular dipole, molecular geometry, bond polarity
Section: 1.11, 1.10, 1.5
Difficulty Level: Hard

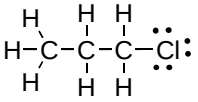
138. Of the molecules listed, which does *not* have a dipole moment?
A) HCl
B) NCl_3
C) CO
D) BF_3
E) All molecules have a dipole moment.
Ans: D

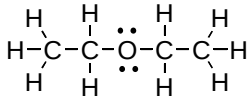
Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

139. Which of the compounds listed below would be expected to have the *highest* boiling point? (They all have approximately the same molecular weight.)


I


II

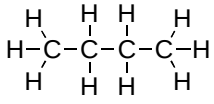

III


IV

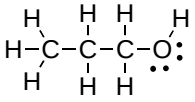
A) I
B) II
C) III
D) IV
E) II and IV would both have the highest boiling point
Ans: B

Topic: Physical Properties, Comparison
Section: 1.12
Difficulty Level: Easy

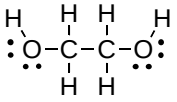
140. Of the molecules given, which is expected to have the *lowest* boiling point?



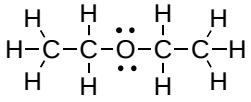
I



II



III



IV

A) I
B) II
C) III
D) IV
E) II and IV would both have the lowest boiling point
Ans: A

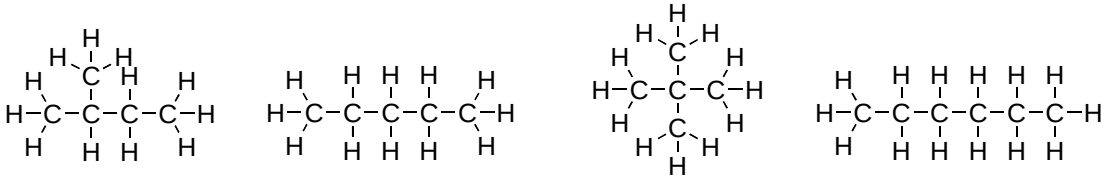
Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

141. Of the molecules given, which is expected to have the *lowest* boiling point?

A) CH_3Cl
B) CH_4
C) CH_2Cl_2
D) $CHCl_3$
E) CCl_4
Ans: B

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

142. Of the molecules given, which is expected to have the *lowest* boiling point?

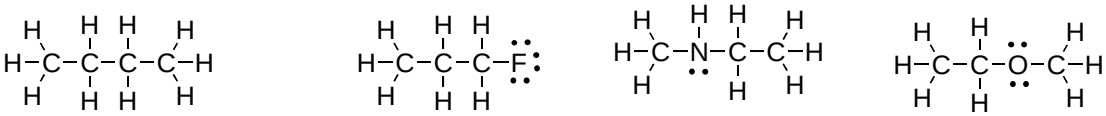


I II III IV

A) I
B) II
C) III
D) IV
E) I, II and IV would all have the lowest boiling point
Ans: C

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Moderate

143. Which of the compounds below is capable of forming hydrogen bonds between like molecules?

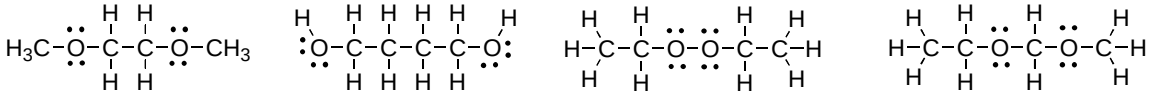


I II III IV

A) I
B) II
C) III
D) IV
E) II, III, and IV would each be capable of hydrogen bonding to a respectively identical molecule
Ans: C

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

144. Of the molecules given, which is expected to have the *highest* boiling point?

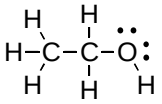


I II III IV

A) I
B) II
C) III
D) IV
E) Not enough information to determine
Ans: B

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

145. What is the strongest intermolecular force present in liquid ethanol?

Ethanol = 

A) induced dipole-induced dipole
B) dipole-dipole, specifically hydrogen bonding
C) dipole-dipole, but not hydrogen bonding
D) ion-dipole
E) ion-ion
Ans: B

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

146. Which attractive intermolecular force is generally considered the *strongest*?

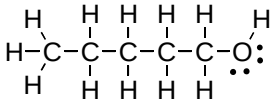
A) London dispersion forces
B) Dipole-dipole interactions
C) Fleeting dipole-dipole interactions
D) The Vital force
E) Hydrogen bonding
Ans: E

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

147. Which attractive intermolecular force is generally considered the *weakest*?
    A) Ion-ion
    B) London dispersion forces
    C) Dipole-dipole
    D) Covalent bonding
    E) Hydrogen bonding
    Ans: B

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

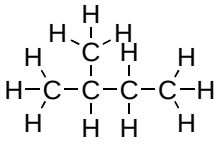
148. Which, of the intermolecular forces listed, would not form between like molecules of the following structure?



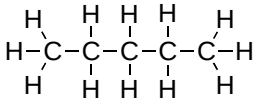
    A) Ion-ion
    B) London dispersion forces
    C) Dipole-dipole
    D) Fleeting dipole-dipole
    E) Hydrogen bonding
    Ans: A

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

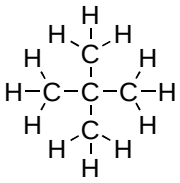
149. Of the following molecules, known as alkanes, which is expected to have the *highest* melting point?



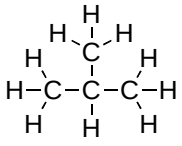
I



II



III



IV

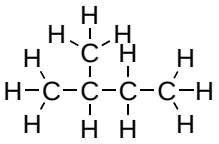
A) I
B) II
C) III
D) IV
E) I, II, and III have equal carbon atoms and thus the same melting point
Ans: B

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

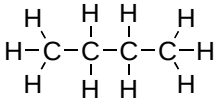
150. Which intermolecular force is primarily responsible for base pairing, and stability, of the double helix in DNA?
A) Ion-ion
B) Dipole-dipole
C) Hydrogen bonds
D) London dispersion forces
E) Covalent bonds
Ans: C

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Moderate

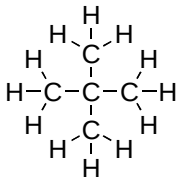
151. Of the following molecules, which are expected to have the *greatest* fleeting dipole interactions between like molecules?



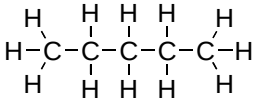
I



II



III

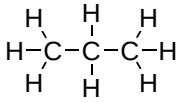


IV

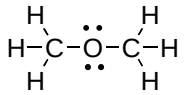
A) I
B) II
C) III
D) IV
E) I, III, and IV have equal carbon atoms and thus equal interactions
Ans: D

Topic: Solubility
Section: 1.13
Difficulty Level: Easy

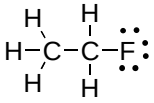
152. Which of the following compounds is expected to be the *most* soluble in H_2O?



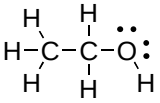
I



II



III

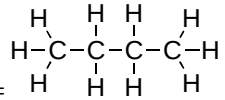


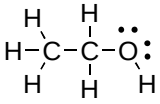
IV

A) I
B) II
C) III
D) IV
E) II and IV would be equally soluble in water
Ans: D

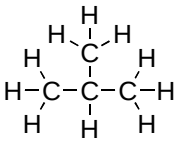
Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Moderate

153. Of the given molecules, which would be expected to have the *greatest* solubility in the solvent butane?

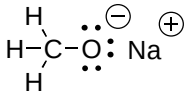
Butane = 



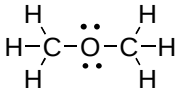
I



II



III



IV

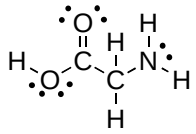
A) I
B) II
C) III
D) IV
E) I and IV would have equal solubility in butane
Ans: B

Topic: Intermolecular forces
Section: 1.13
Difficulty Level: Moderate

154. For soap to remove and dissolve oil in water, what molecular features are needed?
A) One end of the molecule must be polar
B) The compound must contain oxygen atoms
C) One end of the molecule must be nonpolar
D) A and C are required
E) A, B, and C are required
Ans: D

Topic: Solubility, Intermolecular forces
Section: 1.13, 1.11
Difficulty Level: Moderate

155. The example below is of an amino acid, the building blocks of proteins. Pick the statement that best predicts an amino acid's physical properties.



A) high melting points and low solubility in water
B) large dipole moments and no hydrogen bonding
C) high melting points and large dipole moments
D) low solubility in water and small dipole moments
E) small dipole moments and are hydrophobic
Ans: C

SHORT ANSWER QUESTIONS

Topic: General
Section: Introduction
Difficulty Level: Easy

156. Modern organic chemistry is generally defined as _____.

    Ans: the study of carbon compounds

Topic: General
Section: 1.1
Difficulty Level: Easy

157. In the early understanding of chemistry, organic compounds were defined as only those molecules obtained from _____.

    Ans: living sources/organisms

Topic: Isomers
Section: 1.1
Difficulty Level: Easy

158. Compounds that are not identical, but have the same molecular formula, are referred to as _____.

    Ans: isomers

Topic: Isomers
Section: 1.1
Difficulty Level: Easy

159. Constitutional isomers differ only by _____.

    Ans: the connectivity of their atoms

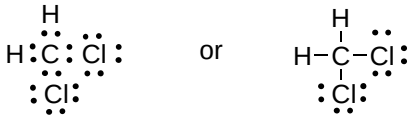
Topic: Bonding
Section: 1.2
Difficulty Level: Easy

160. In compounds where the nitrogen atom bears no formal charge, the typical valence of the nitrogen atom is _____.

Ans: three

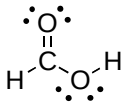
Topic: Lewis Structures
Section: 1.3
Difficulty Level: Easy

161. Draw a valid Lewis structure, showing all nonbonding electrons, for dichloromethane, CH_2Cl_2.

Ans:  or

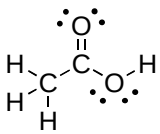
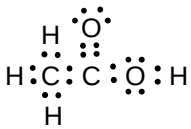
Topic: Lewis Structures
Section: 1.3
Difficulty Level: Moderate

162. Provide a valid Lewis structure for a molecule with the molecular formula CH_2O_2.

Ans: 

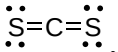
Topic: Lewis Structures
Section: 1.3
Difficulty Level: Moderate

163. Draw the Lewis structure of acetic acid, CH_3CO_2H, clearly indicating all non–bonding pairs of electrons.

Ans:  or 

Topic: Lewis structures, atomic orbital hybridization, molecular geometry
Section: 1.3, 1.9, 1.10
Difficulty Level: Moderate

164. Consider the molecule carbon disulfide, CS_2: a) provide a Lewis structure b) illustrate the correct molecular geometry c) indicate the hybridization of all atoms d) identify the bond angle around carbon e) explain if the molecule is polar or nonpolar.

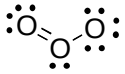
Ans:  , sp^2, sp, sp^2, linear, 180°
The molecule is nonpolar as the molecular geometry is linear and symmetrical. The individual C–S bond polarities cancel for a net molecular dipole of zero.

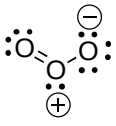
Topic: Lewis structures, atomic orbital hybridization, molecular geometry
Section: 1.3, 1.9, 1.10
Difficulty Level: Moderate

165. Provide a Lewis structure for acetonitrile, CH_3CN, illustrating the hybridization, geometry and bond angle of each carbon.
Ans: $CH_3–C\equiv N:$, $CH_3 – sp^3$, tetrahedral, 109.5°; C – *sp*, linear, 180°

Topic: Formal Charge
Section: 1.4
Difficulty Level: Easy

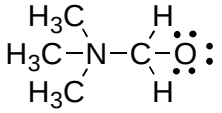
166. Redraw the Lewis structure of ozone, the molecule below, assigning the correct formal charge to each oxygen atom.



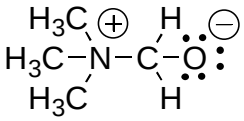
Ans: 

Topic: Formal Charge
Section: 1.4
Difficulty Level: Easy

167. For the molecule below, add formal charges to all atoms where they are not zero.



Ans:



Topic: Bonding
Section: 1.5
Difficulty Level: Easy

168. The bond formed from the sharing of a pair of electrons is classified as a _____.

Ans: covalent bond

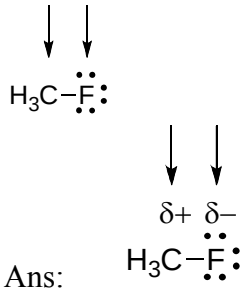
Topic: Electronegativity
Section: 1.5
Difficulty Level: Easy

169. What atomic property is considered in determining if a covalent bond is polar or nonpolar?

Ans: Electronegativity

Topic: Bond polarity
Section: 1.5
Difficulty Level: Easy

170. Using δ+ and δ– notation, indicate any partial charges on the atoms indicated in the molecule below.



Ans:

Topic: Bonding
Section: 1.6
Difficulty Level: Easy

171. An orbital is defined as a region of space with a high probability of _____.

Ans: finding an electron

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

172. The element with the electronic configuration $1s^2\,2s^2\,2p^6\,3s^1$ is _____.

Ans: sodium

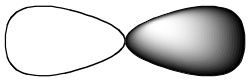
Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

173. Provide the electron configuration of sulfur.

Ans: $1s^2\,2s^2\,2p^6\,3s^2\,3p^4$

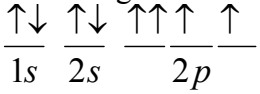
Topic: Atomic orbital theory
Section: 1.6
Difficulty Level: Easy

174. Draw the shape of a 2p orbital.

Ans: 

Topic: Electron configuration
Section: 1.6
Difficulty Level: Moderate

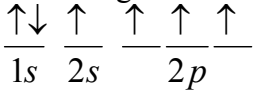
175. The electron configuration for oxygen, shown below, violates what principle of describing an atoms electron configurations?



Ans: The Pauli exclusion principle

Topic: Electron configuration
Section: 1.6
Difficulty Level: Moderate

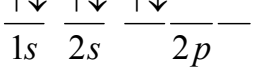
176. The electron configuration for carbon, shown below, violates what principle of describing an atoms ground-state electron configurations?



Ans: The Aufbau principle

Topic: Electron configuration
Section: 1.6
Difficulty Level: Moderate

177. The electron configuration for carbon, shown below, violates what principle of describing an atoms electron configurations?



Ans: Hund's Rule

Topic: Molecular orbital theory
Section: 1.8
Difficulty Level: Moderate

178. Molecular orbitals resulting from the overlap of atomic orbitals of opposite phase are referred to as _____.

Ans: antibonding orbitals

Topic: Molecular orbital theory
Section: 1.8
Difficulty Level: Moderate

179. Molecular orbitals resulting from the overlap of atomic orbitals of the same phase are referred to as _____.

Ans: bonding orbital

Topic: Electron configuration
Section: 1.6
Difficulty Level: Easy

180. Ar, K^+, and Cl^- have equal numbers of electrons, and are considered isoelectronic. Write out the electron configuration for all these species.

Ans: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Topic: Hybridized atomic orbitals and bonding
Section: 1.9
Difficulty Level: Moderate

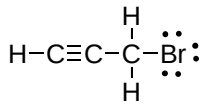
181. The formation of sigma (σ) and pi (π) results from the overlap of atomic orbitals. Describe the differences between sigma and pi bonds.

Ans: Sigma bonds are formed from the overlap of atomic orbitals along a circular axis of symmetrical nature, i.e., head–on overlap. All single bonds are sigma bonds.

Pi bonds are formed from the overlap of atomic orbitals along a non–symmetrical (parallel) axis, i.e., side–to–side overlap. Double and triple bonds contain both sigma and pi bonds.

Topic: Atomic orbital hybridization
Section: 1.9
Difficulty Level: Easy

182. Moving from left to right, assign the correct hybridization of the carbon atoms in the molecule below:

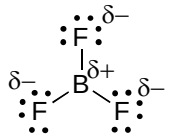


Ans: *sp*, *sp*, sp^3

Topic: Molecular polarity, Lewis structures
Section: 1.11, 1.3
Difficulty Level: Moderate

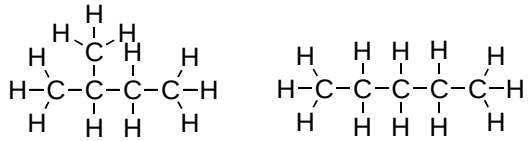
183. BF_3 has a dipole moment of zero. a) Draw the Lewis structure for BF_3, showing all nonbonding electrons. b) Indicate the polarity of every atom in the structure using δ+ and δ– notation, and c) explain why the molecule has a net dipole of zero.

Ans: The trigonal planar geometry of BF_3 results in the canceling of individual bond polarities, producing a net molecular dipole of zero.



Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

184. Explain why molecule **I** has a lower boiling point than molecule **II**.



I II

Ans: Like molecules of II have greater contact area than like molecules of I. The increased extent of intermolecular interactions between like molecules of II requires more energy be applied to separate the molecules in the liquid phase as they pass to the gas phase. Therefore, the boiling point of molecule II is higher.

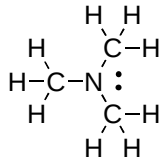
Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

185. The interaction between alkanes is primarily due to which intermolecular force?

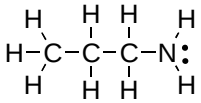
Ans: London dispersion forces

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

186. Explain why trimethylamine, $(CH_3)_3N$**:**, has a considerably *lower* boiling point than *n*-propylamine, $CH_3CH_2CH_2NH_2$, even though the compounds are constitutional isomers.



Trimethylamine

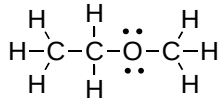


n-Propylamine

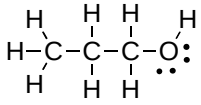
Ans: Hydrogen bonding is possible for *n*-propylamine due to a lone pair and H atom on the nitrogen. There is no H atom attached to the nitrogen of trimethylamine that may interact with the lone pair of electrons, consequently the boiling point is higher for propylamine.

Topic: Intermolecular forces
Section: 1.12
Difficulty Level: Easy

187. Which of the molecules shown below would be expected to have the *higher* boiling point? Briefly explain your choice.



or



I II

Ans: $CH_3CH_2CH_2OH$ has the higher boiling point since it is capable of intermolecular hydrogen bonding.

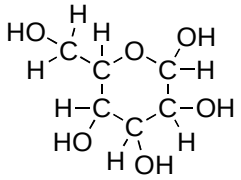
Topic: Solubility
Section: 1.13
Difficulty Level: Easy

188. Which of the compounds shown below would be expected to be *more* soluble in water? Briefly explain your choice.
CH_3OCH_3 or CH_3CH_2OH

Ans: CH_3CH_2OH is more soluble in water since it can donate a hydrogen bond to water and accept a hydrogen bond from water. CH_3OCH_3 can only accept a hydrogen bond from water.

Topic: Solubility, Intermolecular forces
Section: 1.13, 1.11
Difficulty Level: Moderate

189. Sugars, an example of which is shown below, tend to be very soluble in water. Offer a brief explanation of the factors involved in making sugars water-soluble.



(The lone pairs of electrons on the oxygen atoms have been removed for clarity)

Ans: Favorable hydrogen bonding between the sugar and water readily occurs as both contain O–H groups capable of hydrogen bonding.

Topic: Solubility
Section: 1.13
Difficulty Level: Hard

190. Describe how soaps function as cleaning agents.

Ans: Soaps form clusters called micelles. The polar groups of the soaps form the surface of the micelle and hydrogen bond to the surrounding water. The interior of the micelle is composed of the nonpolar, hydrophobic portions of the soap molecules. Grease and dirt are nonpolar and have limited solubility in water. In soapy water however, grease and dirt will dissolve in the nonpolar interior of the soap micelles, which in turn are soluble in the water.