Chapter 10: Chemical Bonding II: Molecular Geometry and Hybridization of Atomic Orbitals

1. Give the number of lone pairs around the central atom and the molecular geometry of CBr_4.
   A) 0 lone pairs, square planar
   B) 0 lone pairs, tetahedral
   C) 1 lone pair, square pyramidal
   D) 1 lone pair, trigonal bipyramidal
   E) 2 lone pairs, square planar
   Ans: B Category: Medium Section: 10.1

2. Give the number of lone pairs around the central atom and the molecular geometry of SCl_2.
   A) 0 lone pairs, linear
   B) 1 lone pair, bent
   C) 2 lone pairs, bent
   D) 3 lone pairs, bent
   E) 3 lone pairs, linear
   Ans: C Category: Medium Section: 10.1

3. Give the number of lone pairs around the central atom and the molecular geometry of XeF_2.
   A) 0 lone pairs, linear
   B) 1 lone pair, bent
   C) 2 lone pairs, bent
   D) 3 lone pairs, bent
   E) 3 lone pairs, linear
   Ans: E Category: Medium Section: 10.1

4. Give the number of lone pairs around the central atom and the molecular geometry of SeF_4.
   A) 0 lone pairs, tetrahedral
   B) 1 lone pair, distorted tetrahedron (seesaw)
   C) 1 lone pair, square pyramidal
   D) 1 lone pair, tetrahedral
   E) 2 lone pairs, square planar
   Ans: B Category: Medium Section: 10.1

5. Give the number of lone pairs around the central atom and the molecular geometry of XeF_4.
   A) 0 lone pairs, tetrahedral
   B) 1 lone pair, distorted tetrahedron (seesaw)
   C) 1 lone pair, square pyramidal
   D) 1 lone pair, tetrahedral
   E) 2 lone pairs, square planar
   Ans: E Category: Medium Section: 10.1

6. Give the number of lone pairs around the central atom and the molecular geometry of IF_5.
   A) 0 lone pairs, square pyramidal
   B) 0 lone pairs, trigonal bipyramidal
   C) 1 lone pair, octahedral
   D) 1 lone pair, square pyramidal
   E) 2 lone pairs, pentagonal
   Ans: D Category: Medium Section: 10.1

7. Give the number of lone pairs around the central atom and the geometry of the ion SeO_4^{2-}.
   A) 0 lone pairs, square planar
   B) 0 lone pairs, tetrahedral
   C) 1 lone pair, distorted tetrahedron (seesaw)
   D) 1 lone pair, square pyramidal
   E) 2 lone pairs, square planar
   Ans: B Category: Medium Section: 10.1

8. Give the number of lone pairs around the central atom and the geometry of the ion PCl_4^-.
   A) 0 lone pairs, tetrahedral
   B) 1 lone pair, distorted tetrahedron (seesaw)
   C) 1 lone pair, square pyramidal
   D) 1 lone pair, tetrahedral
   E) 2 lone pairs, square planar
   Ans: B Category: Medium Section: 10.1

9. Give the number of lone pairs around the central atom and the geometry of the ion IBr_2^-.
   A) 0 lone pairs, linear
   B) 1 lone pair, bent
   C) 2 lone pairs, bent
   D) 3 lone pairs, bent
   E) 3 lone pairs, linear
   Ans: E Category: Medium Section: 10.1

10. Give the number of lone pairs around the central atom and the geometry of the ion ClO_2^-.
    A) 0 lone pairs, linear
    B) 1 lone pair, bent
    C) 2 lone pairs, bent
    D) 3 lone pairs, bent
    E) 3 lone pairs, linear
    Ans: C Category: Medium Section: 10.1

11. Give the number of lone pairs around the central atom and the geometry of the ion ClO_3^-.
    A) 0 lone pairs, trigonal
    B) 1 lone pair, bent
    C) 1 lone pair, trigonal pyramidal
    D) 2 lone pairs, T-shaped
    E) 2 lone pairs, trigonal
    Ans: C Category: Medium Section: 10.1

12. Give the number of lone pairs around the central atom and the geometry of the ion NO_2^-.
    A) 0 lone pairs, linear
    B) 1 lone pair, bent
    C) 2 lone pair, bent
    D) 3 lone pairs, bent
    E) 3 lone pairs, linear
    Ans: B Category: Medium Section: 10.1

13. According to the VSEPR theory, the geometry of the SO_3 molecule is
    A) pyramidal.
    B) tetrahedral.
    C) trigonal planar.
    D) distorted tetrahedron (seesaw).
    E) square planar.
    Ans: C Category: Medium Section: 10.1

14. The geometry of the SF_4 molecule is
    A) tetrahedral.
    B) trigonal pyramidal.
    C) trigonal planar.
    D) square planar.
    E) distorted tetrahedron (seesaw).
    Ans: E Category: Medium Section: 10.1

15. Use VSEPR theory to predict the geometry of the PCl_3 molecule.
    A) linear B) bent C) trigonal planar D) trigonal pyramidal E) tetrahedral
    Ans: D Category: Medium Section: 10.1

16. According to VSEPR theory, the geometry of the PH_3 molecule is best described as
    A) linear. B) trigonal planar. C) tetrahedral. D) bent. E) trigonal pyramidal.
    Ans: E Category: Medium Section: 10.1

17. The geometry of the CS_2 molecule is best described as
    A) linear. B) trigonal planar. C) tetrahedral. D) bent. E) trigonal pyramidal.
    Ans: A Category: Medium Section: 10.1

18. The geometry of the ClF_3 molecule is best described as:
    A) distorted tetrahedron
    B) trigonal planar
    C) tetrahedral
    D) T-shaped
    E) trigonal pyramidal
    Ans: D Category: Medium Section: 10.1

19. According to the VSEPR theory, the molecular geometry of the carbonate ion, CO_3^{2-}, is
    A) square planar.
    B) tetrahedral.
    C) pyramidal.
    D) trigonal planar.
    E) octahedral.
    Ans: D Category: Medium Section: 10.1

20. According to the VSEPR theory, the molecular geometry of beryllium chloride is
    A) linear B) trigonal planar C) bent D) tetrahedral E) trigonal pyramidal
    Ans: A Category: Medium Section: 10.1

21. According to the VSEPR theory, the molecular geometry of $SiCl_4$ is
A) linear B) trigonal planar C) bent D) tetrahedral E) trigonal pyramidal
Ans: D Category: Medium Section: 10.1

22. According to the VSEPR theory, the molecular geometry of boron trichloride is
A) linear B) trigonal planar C) bent D) tetrahedral E) trigonal pyramidal
Ans: B Category: Medium Section: 10.1

23. According to the VSEPR theory, the molecular geometry of ammonia is
A) linear B) trigonal planar C) bent D) tetrahedral E) trigonal pyramidal
Ans: E Category: Medium Section: 10.1

24. According to the VSEPR theory, which one of the following species should be *linear*?
A) H_2S B) HCN C) BF_3 D) H_2CO E) SO_2
Ans: B Category: Medium Section: 10.1

25. According to VSEPR theory, which one of the following molecules should have a geometry that is *trigonal bipyramidal*?
A) SF_4 B) XeF_4 C) NF_3 D) SF_6 E) PF_5
Ans: E Category: Medium Section: 10.1

26. According to VSEPR theory, which one of the following molecules should be *nonlinear*?
A) CO_2 B) C_2H_2 C) SO_2 D) $BeCl_2$ E) KrF_2
Ans: C Category: Medium Section: 10.1

27. Which one of the following molecules has tetrahedral geometry?
A) XeF_4 B) BF_3 C) AsF_5 D) CF_4 E) NH_3
Ans: D Category: Medium Section: 10.1

28. According to VSEPR theory, which one of the following molecules has tetrahedral geometry?
A) NH_3 B) CCl_4 C) CO_2 D) SF_4 E) PCl_5
Ans: B Category: Medium Section: 10.1

29. According to VSEPR theory, which one of the following species has a tetrahedral geometry?
A) IF_4^+ B) IF_4^- C) PCl_4^+ D) PCl_4^- E) SeF_4
Ans: C Category: Medium Section: 10.1

30. Predict the geometry around the central atom in PO_4^{3-}.
A) trigonal planar
B) trigonal pyramidal
C) tetrahedral
D) trigonal bipyramidal
E) octahedral
Ans: C Category: Medium Section: 10.1

31. Predict the geometry around the central atom in SO_4^{2-}.
    A) trigonal planar
    B) trigonal pyramidal
    C) tetrahedral
    D) trigonal bipyramidal
    E) octahedral
    Ans: C Category: Medium Section: 10.1

32. Predict the geometry around the central atom in XeO_4.
    A) trigonal planar
    B) trigonal pyramidal
    C) tetrahedral
    D) trigonal bipyramidal
    E) octahedral
    Ans: C Category: Medium Section: 10.1

33. Which of the following substances is/are *bent*?
    (i) H_2S (ii). CO_2 (iii) ClNO (iv) NH_2^- (v) O_3
    A) only (iii)
    B) only (i) and (v)
    C) only (i), (iii), and (v)
    D) all are bent except for (iv)
    E) all are bent except for (ii)
    Ans: E Category: Medium Section: 10.1

34. Which of the following substance is/are *planar*?
    (i) SO_3 (ii) SO_3^{2-} (iii) NO_3^- (iv) PF_3 (v) BF_3
    A) only (i) and (ii)
    B) only (i), (iii), and (v)
    C) only (iv)
    D) all are planar except (iv)
    E) all are planar except (ii)
    Ans: B Category: Medium Section: 10.1

35. The bond angle in SCl_2 is expected to be
    A) a little less than 109.5°.
    B) 109.5°.
    C) a little more than 109.5°.
    D) 120°.
    E) 180°.
    Ans: A Category: Medium Section: 10.1

36. The bond angle in ICl_2^- is expected to be
    A) a little less than 109.5°.
    B) 109.5°.
    C) a little more than 109.5°.
    D) 120°.
    E) 180°.
    Ans: E Category: Medium Section: 10.1

37. The bond angles in SF_5^+ are expected to be
    A) 90°.
    B) 120°.
    C) 90° and 120°.
    D) 90° and 180°.
    E) 90°, 120°, and 180°.
    Ans: E Category: Medium Section: 10.1

38. The bond angles in CO_3^{2-} are expected to be
    A) a little less than 109.5°.
    B) 109.5°.
    C) a little less than 120°.
    D) 120°.
    E) a little more than 120°.
    Ans: D Category: Medium Section: 10.1

39. The bond angle in Cl_2O is expected to be approximately
    A) 90° B) 109.5° C) 120° D) 145° E) 180°
    Ans: B Category: Medium Section: 10.1

40. The F – S – F bond angles in SF_6 are
    A) 90° and 180° B) 109.5° C) 120° D) 180° E) 90° and 120°
    Ans: A Category: Medium Section: 10.1

41. The F –Cl –F bond angles in ClF_3 are expected to be approximately
    A) 90° only.
    B) 109.5° only.
    C) 120° only.
    D) 180° only.
    E) 90° and 180°.
    Ans: E Category: Medium Section: 10.1

42. According to the VSEPR theory, the *actual* F –As –F bond angles in the AsF_4^- ion are predicted to be
    A) 109.5° B) 90° and 120° C) 180° D) < 109.5° E) < 90° and < 120°
    Ans: E Category: Medium Section: 10.1

43. The C–N–O bond angle in nitromethane, CH_3NO_2, is expected to by approximately
    A) 60° B) 90° C) 109.5° D) 120° E) 180°
    Ans: D Category: Medium Section: 10.1

44. Which one of the following molecules is *nonpolar*?
    A) NH_3 B) OF_2 C) CH_3Cl D) H_2O E) $BeCl_2$
    Ans: E Category: Medium Section: 10.2

45. Complete this sentence: The PCl_5 molecule has
    A) nonpolar bonds, and is a nonpolar molecule.
    B) nonpolar bonds, but is a polar molecule.
    C) polar bonds, and is a polar molecule.
    D) polar bonds, but is a nonpolar molecule.
    Ans: D Category: Medium Section: 10.2

46. Which one of the following molecules has a non-zero dipole moment?
    A) $BeCl_2$ B) Br_2 C) BF_3 D) IBr E) CO_2
    Ans: D Category: Medium Section: 10.2

47. Which one of the following molecules has a zero dipole moment?
A) CO B) CH_2Cl_2 C) SO_3 D) SO_2 E) NH_3
Ans: C Category: Medium Section: 10.2

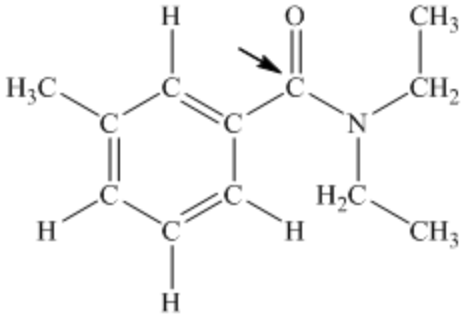
48. Which one of the following molecules is polar?
A) PBr_5 B) CCl_4 C) BrF_5 D) XeF_2 E) XeF_4
Ans: C Category: Medium Section: 10.2

49. Predict the molecular geometry and polarity of the SO_2 molecule.
A) linear, polar
B) linear, nonpolar
C) bent, polar
D) bent, nonpolar
E) None of the above.
Ans: C Category: Medium Section: 10.2

50. Predict the geometry and polarity of the CS_2 molecule.
A) linear, polar
B) linear, nonpolar
C) tetrahedral, nonpolar
D) bent, nonpolar
E) bent, polar
Ans: B Category: Medium Section: 10.2

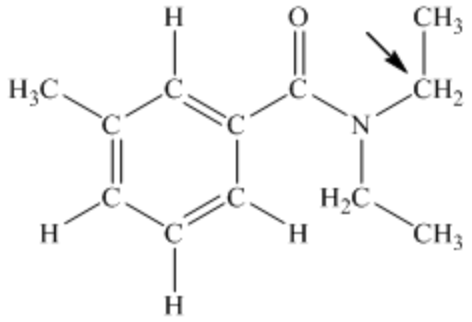
51. Which of the following species has the largest dipole moment (i.e., is the most polar)?
A) CH_4 B) CH_3Br C) CH_3Cl D) CH_3F E) CH_3I
Ans: D Category: Medium Section: 10.2

52. *N*,*N*-diethyl-*m*-tolumide (DEET) is the active ingredient in many mosquito repellents. What is the hybridization state of carbon indicated by the arrow in the structure of DEET shown below?



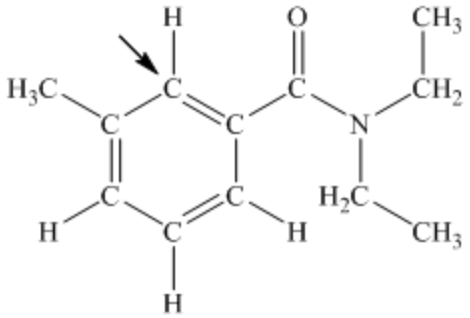
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: B Category: Medium Section: 10.4

53. *N*,*N*-diethyl-*m*-tolumide (DEET) is the active ingredient in many mosquito repellents. What is the hybridization state of carbon indicated by the arrow in the structure of DEET shown below?



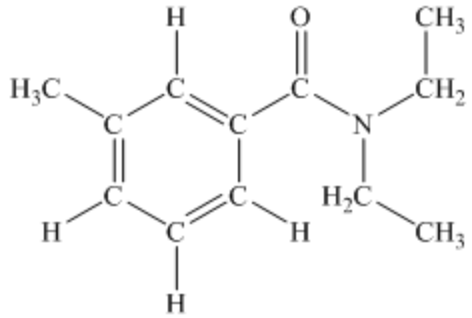
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

54. *N*,*N*-diethyl-*m*-tolumide (DEET) is the active ingredient in many mosquito repellents. What is the hybridization state of carbon indicated by the arrow in the structure of DEET shown below?



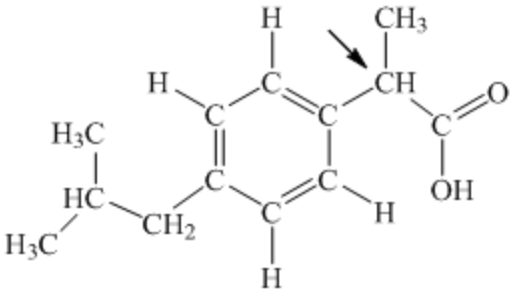
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: B Category: Medium Section: 10.4

55. *N*,*N*-diethyl-*m*-tolumide (DEET) is the active ingredient in many mosquito repellents. What is the hybridization state of the nitrogen atom in the structure of DEET shown below?



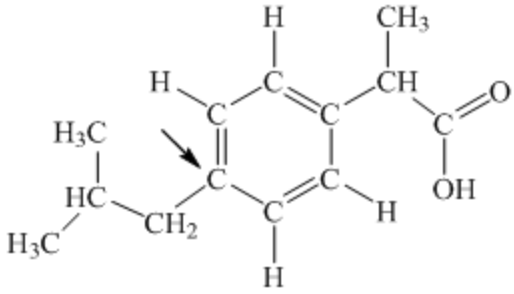
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

56. Ibuprofen is used as an analgesic for the relief of pain, and also to help reduce fever. What is the hybridization state of carbon indicated by the arrow in the structure of ibuprofen shown below?



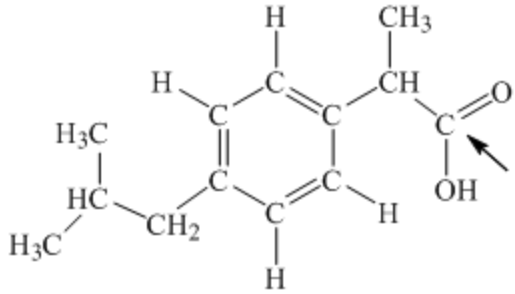
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

57. Ibuprofen is used as an analgesic for the relief of pain, and also to help reduce fever. What is the hybridization state of carbon indicated by the arrow in the structure of ibuprofen shown below?



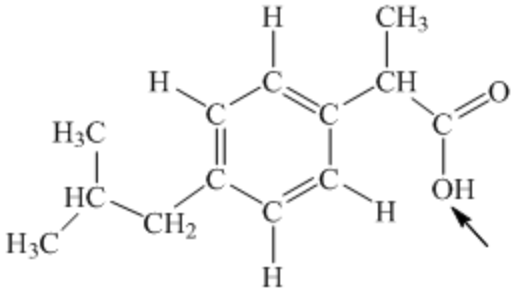
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: B Category: Medium Section: 10.4

58. Ibuprofen is used as an analgesic for the relief of pain, and also to help reduce fever. What is the hybridization state of carbon indicated by the arrow in the structure of ibuprofen shown below?



A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: B Category: Medium Section: 10.4

59. Ibuprofen is used as an analgesic for the relief of pain, and also to help reduce fever. What is the hybridization state of oxygen indicated by the arrow in the structure of ibuprofen shown below?



A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

60. Indicate the type of hybrid orbitals used by the central atom in PCl_3.
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

61. Indicate the type of hybrid orbitals used by the central atom in CCl_4.
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

62. Indicate the type of hybrid orbitals used by the central atom in SF_6.
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: E Category: Medium Section: 10.4

63. What is the hybridization of the As atom in the AsF_5 molecule?
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: D Category: Medium Section: 10.4

64. Indicate the type of hybrid orbitals used by the central atom in TeF_4.
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: D Category: Medium Section: 10.4

65. Indicate the type of hybrid orbitals used by the central atom in BrF_3.
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: D Category: Medium Section: 10.4

66. What is the hybridization of the iodine atom in the IF_5 molecule?
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: E Category: Medium Section: 10.4

67. What is the hybridization on the central atom in NO_3^-?
A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: B Category: Medium Section: 10.5

68. In which one of the following molecules is the central atom sp^2 hybridized?
A) SO_2 B) N_2O C) $BeCl_2$ D) NF_3 E) PF_5
Ans: A Category: Medium Section: 10.5

69. What is the hybridization of As in the AsF_4^- ion?
A) sp B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: D Category: Medium Section: 10.4

70. What is the hybridization of the central atom in ClO_3^-?
A) sp B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: C Category: Medium Section: 10.4

71. The hybridization of the central nitrogen atom in the molecule N_2O is
A) sp B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2
Ans: A Category: Medium Section: 10.5

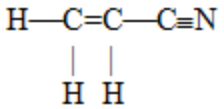
72. If a triatomic molecule is linear, then the hybridization of the central atom will be
A) sp B) sp^2 C) sp or sp^3 D) sp or sp^3d E) sp^2 or sp^3d^2
Ans: D Category: Medium Section: 10.4

73. In which of these molecules do the two nitrogen atoms have different hybridizations?
A) NH_4NO_3 B) N_2H_4 C) N_2O_4 D) N_2O_5 E) none of these
Ans: A Category: Medium Section: 10.5

74. Which of the following species have the same geometries?
A) NH_2^- and H_2O
B) NH_2^- and BeH_2
C) H_2O and BeH_2
D) NH_2^-, H_2O, and BeH_2
Ans: A Category: Medium Section: 10.1

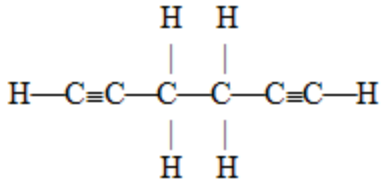
75. Which of the following molecules have the same geometries?
A) SF_4 and CH_4 B) CO_2 and H_2O C) CO_2 and BeH_2 D) N_2O and NO_2
Ans: C Category: Medium Section: 10.1

76. The number of pi bonds in the molecule below is



A) 1 B) 2 C) 3 D) 5 E) 9
Ans: C Category: Medium Section: 10.5

77. The number of pi bonds in the molecule below is



A) 2 B) 4 C) 6 D) 10 E) 15
Ans: B Category: Medium Section: 10.5

78. The number of pi bonds in the oxalate ion ($C_2O_4^{2-}$) is
A) 1 B) 2 C) 3 D) 4 E) 5
Ans: B Category: Difficult Section: 10.5

79. Consider the species Cl_2^+, Cl_2, and Cl_2^-. Which of these species will be paramagnetic?
A) only Cl_2
B) Cl_2^+ and Cl_2
C) Cl_2 and Cl_2^-
D) Cl_2^+ and Cl_2^-
E) all three are paramagnetic
Ans: D Category: Difficult Section: 10.7

80. Consider the species O_2^-, O_2, and O_2^+. Which of these species will be paramagnetic?
A) O_2 and O_2^-
B) O_2^+ and O_2
C) O_2^+ and O_2^-
D) only O_2
E) all three are paramagnetic
Ans: E Category: Difficult Section: 10.7

81. Consider the species N_2^-, N_2, and N_2^+. Which of these species will be paramagnetic?
A) N_2 and N_2^-
B) N_2^+ and N_2
C) N_2^+ and N_2^-
D) only N_2^-
E) none are paramagnetic
Ans: C Category: Difficult Section: 10.7

82. In which of the following would the bonding be *strengthened* with the addition of an electron to form the negative molecular ion?
A) N_2 B) O_2 C) F_2 D) all of these E) none of these
Ans: E Category: Difficult Section: 10.7

83. In which of the following would the bonding be *strengthened* with the addition of an electron to form the negative molecular ion?
A) C_2 B) O_2 C) N_2 D) all of these E) none of these
Ans: A Category: Difficult Section: 10.7

84. In which of the following would the bonding be *weakened* with the addition of an electron to form the negative molecular ion?
A) B_2 B) C_2 C) N_2 D) all of these E) none of these
Ans: C Category: Difficult Section: 10.7

85. In which of the following would the bonding be *weakened* with the addition of an electron to form the negative molecular ion?
A) N_2 B) O_2 C) F_2 D) all of these E) none of these
Ans: D Category: Difficult Section: 10.7

86. Which of the following is *not* true of molecular orbitals?
A) The number of molecular orbitals formed is always equal to the number of atomic orbitals combined.
B) A molecular orbital can accommodate up to two electrons.
C) When electrons are added to orbitals of the same energy, the most stable arrangement is predicted by Hund's rule.
D) Low-energy molecular orbitals fill before high-energy molecular orbitals fill.
E) For any substance, the number of electrons in molecular orbitals is equal to the sum of all the valence electrons on the bonding atoms.
Ans: E Category: Medium Section: 10.7

87. The electrons in the delocalized molecular orbitals of benzene (C_6H_6)
A) are confined between two adjacent bonding atoms.
B) are free to move around the six-membered ring.
C) form the electron pairs in the C–H bonds of the compound.
D) are unevenly distributed through the molecule.
E) are responsible for the fact that the bonds between three pairs of carbon atoms in the ring are longer and stronger than the bonds between the other three pairs of carbon atoms.
Ans: B Category: Medium Section: 10.8

88. Which of the following correctly lists species in order of *increasing* bond length?
A) $O_2 < O_2^+ < O_2^-$
B) $O_2^- < O_2 < O_2^+$
C) $O_2^+ < O_2 < O_2^-$
D) $O_2^- < O_2^+ < O_2$
E) $O_2^+ < O_2^- < O_2$
Ans: C Category: Medium Section: 10.7

89. Which of the following correctly lists species in order of *increasing* bond length?
A) $C_2^- < C_2 < C_2^+$
B) $C_2 < C_2^+ < C_2^-$
C) $C_2^- < C_2^+ < C_2$
D) $C_2^+ < C_2 < C_2^-$
E) $C_2^+ < C_2^- < C_2$
Ans: A Category: Medium Section: 10.7

90. Which of the following correctly lists species in order of *increasing* bond order?
A) $C_2 < Li_2 < Be_2 < N_2$
B) $Be_2 < Li_2 < C_2 < N_2$
C) $N_2 < Be_2 < Li_2 < C_2$
D) $N_2 < C_2 < Li_2 < Be_2$
E) $Be_2 < C_2 < N_2 < Li_2$
Ans: B Category: Medium Section: 10.7

91. Use VSEPR theory to predict the molecular geometry of H_3O^+ (hydronium ion).
Ans: trigonal pyramidal
Category: Medium Section: 10.1

92. Use VSEPR theory to predict the molecular geometry of CO_3^{2-}.
Ans: trigonal planar
Category: Medium Section: 10.1

93. Use VSEPR theory to predict the molecular geometry of SF_4 (sulfur tetrafluoride).
Ans: distorted tetrahedron (seesaw)
Category: Medium Section: 10.1

94. Use VSEPR theory to explain why the water molecule is bent, rather than linear.
Ans: About the central oxygen atom are two lone pairs and two bonding pairs, with these four electron pairs adopting an (approximately) tetrahedral geometry in order to minimize the electron-electron repulsion. The molecular geometry, reflecting only the orientation of the bonding pairs, is thus bent.
Category: Medium Section: 10.1

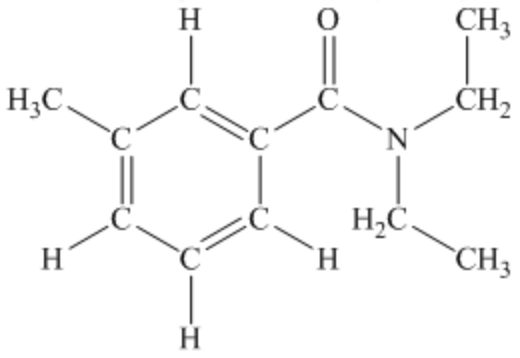
95. According to VSEPR theory, which of the following triatomic ions should be linear: N_3^-, I_3^-, NO_2^-, ClO_2^-, SCN^-.
Ans: N_3^-, I_3^-, and SCN^- are linear
Category: Medium Section: 10.1

96. Using periodic trends, arrange the following molecules in order of increasing dipole moment: NH_3, PH_3, AsH_3.
Ans: $AsH_3 < PH_3 < NH_3$
Category: Medium Section: 10.2

97. Explain why CO_2 is nonpolar, but OCS is polar.
Ans: In CO_2 the two bond moments point in opposite directions and are of equal magnitude. Therefore, they cancel. In OCS, even though the two bond moments point in opposite directions, they are not of the same magnitude and so do not cancel.
Category: Medium Section: 10.2

98. The N – N – H bond angles in hydrazine N_2H_4 are 112°. What is the hybridization of the nitrogen orbitals predicted by valence bond theory?
Ans: sp^3
Category: Medium Section: 10.4

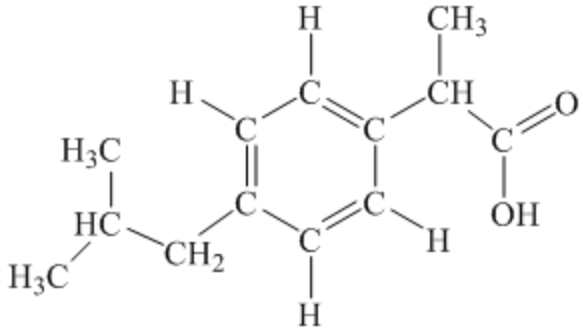
99. *N*,*N*-diethyl-*m*-tolumide (DEET) is the active ingredient in many mosquito repellents.



DEET

How many sigma bonds and pi bonds are contained in a DEET molecule?
Ans: 31 sigma bonds and 4 pi bonds
Category: Medium Section: 10.5

100. Ibuprofen is used as an analgesic for the relief of pain, and also to help reduce fever.



ibuprofen

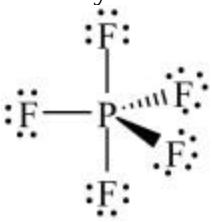
How many sigma bonds and pi bonds are contained in a ibuprofen molecule?
Ans: 33 sigma bonds and 4 pi bonds
Category: Medium Section: 10.5

101. Indicate the number of π–bonds in C_2H_4.
Ans: 1
Category: Medium Section: 10.5

102. Indicate the number of π–bonds in C_2H_6.
Ans: 0
Category: Medium Section: 10.5

103. Indicate the number of π–bonds in N_2H_2.
Ans: 1
Category: Medium Section: 10.5

104. According to the VSEPR theory, the geometrical structure of PF_5 is
Ans: trigonal bipyramidal
Category: Medium Section: 10.1

105. Draw a Lewis structure for PF_5 that shows the correct atom arrangement predicted by VSEPR theory.
Ans: 
Category: Medium Section: 10.1

106. What bond angles are predicted by VSEPR theory for the F –P –F bonds in PF_5?
Ans: 90°, 120°, and 180°
Category: Medium Section: 10.1

107. According to the VSEPR theory, will the molecule PF_5 will be polar or nonpolar?
Ans: nonpolar
Category: Medium Section: 10.2

108. How does the geometrical structure of PF_5 differ from that of IF_5?
Ans: PF_5 is trigonal bipyramidal, whereas IF_5 is square pyramidal
Category: Medium Section: 10.1

109. Ozone (O_3) is an allotropic form of oxygen. Use VSEPR theory to predict the shape of the ozone molecule.
Ans: Bent
Category: Medium Section: 10.1

110. Which should have the longer bond, B_2 or B_2^-?
Ans: B_2
Category: Medium Section: 10.7

111. Which should have the longer bond, O_2 or O_2^+?
Ans: O_2
Category: Medium Section: 10.7

112. Complete the following table.

Hybrid type	Geometry of electron pairs
a _____	linear
b sp^3	_____
c _____	trigonal bipyramidal
d _____	octahedral
e sp^2	_____

Ans:

Hybrid type	Geometry of electron pairs
a sp	linear
b sp^3	tetrahedral
c sp^3d	trigonal bipyramidal
d sp^3d^2	octahedral
e sp^2	trigonal planar

Category: Medium Section: 10.4

113. In benzene (C_6H_6), what is the hybridization of each carbon atom?
Ans: sp^2
Category: Medium Section: 10.8

114. Which of the following molecules should be *polar*?
a. CH_3OH
b. H_2O
c. CH_3OCH_3
Ans: All of these are polar molecules.
Category: Medium Section: 10.2

115. According to the VSEPR theory, all of the electron pair-electron pair repulsions about the central atom in PCl_3 are of equal magnitude.
Ans: False Category: Medium Section: 10.1

116. The BrF_5 molecule has polar bonds and has a net dipole moment.
Ans: True Category: Medium Section: 10.2

117. Pi bonds are covalent bonds in which the electron density is concentrated above and below a plane containing the nuclei of the bonding atoms.
Ans: True Category: Easy Section: 10.5

118. The hybridization of B in the BF_3 molecule is sp^3.
Ans: False Category: Medium Section: 10.4

119. A bonding molecular orbital is of lower energy (more stable) than the atomic orbitals from which it was formed.
Ans: True Category: Medium Section: 10.6

120. A homonuclear diatomic molecule is a molecule composed of three atoms of the same element.
Ans: False Category: Easy Section: 10.7

121. A species with a bond order of 1/2 may be stable.
Ans: True Category: Easy Section: 10.7

122. More energy is required to break a bond with an order of 3/2 than is required to break a bond of order 2.
Ans: False Category: Easy Section: 10.7