Name: _____ Class: _____ Date: _____

**Focus 02: Molecules**

1. Use the expression for the Coulomb potential energy to calculate the energy for formation of 1 mole of sodium chloride ion-pairs, that is, the energy change for the following reaction:

$Na^+(g) + Cl^-(g) \rightarrow Na^+Cl^-(g)$

Use $r_{12} = 283$ pm.

*ANSWER:* $-491\ kJ \cdot mol^{-1}$

2. If 491 $kJ \cdot mol^{-1}$ is released in the reaction $Na^+(g) + Cl^-(g) \rightarrow Na^+Cl^-(g)$, what is the energy change for the reaction $Na(g) + Cl(g) \rightarrow Na^+Cl^-(g)$? (Hint: See the discussion in the text and apply Hess's Law.)

*ANSWER:* $-346\ kJ \cdot mol^{-1}$

3. If 346 $kJ \cdot mol^{-1}$ is released in the reaction $Na(g) + Cl(g) \rightarrow Na^+Cl^-(g)$, is the energy change for the reaction $Na^+Cl^-(g) \rightarrow NaCl(s)$ endothermic or exothermic?

a. Endothermic
b. Exothermic

*ANSWER:* b

4. The Madelung constant is different for all crystals.

a. True
b. False

*ANSWER:* a

5. Use the expression for the Coulomb potential energy to calculate the energy for formation of 1 mole of rubidium chloride ion-pairs, that is, the energy change for the following reaction:

$Rb^+(g) + Cl^-(g) \rightarrow Rb^+Cl^-(g)$

Use $r_{12} = 330$ pm.

*ANSWER:* $-421\ kJ \cdot mol^{-1}$

6. Which of the following has the lowest lattice energy?

a. KBr
b. KCl
c. KI
d. LiCl
e. NaCl

*ANSWER:* c

7. Which of the following has the highest lattice energy?

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a. BaO
b. CaO
c. KI
d. MgO
e. NaCl

*ANSWER:* d

8. Which of the following has the highest melting point?

a. KBr
b. KCl
c. KF
d. KI
e. RbF

*ANSWER:* c

9. Metals rarely lose electrons in chemical reactions because

a. their electron affinities are too high.
b. their ionic radii become too small.
c. their ionization energies are too small.
d. their ionization energies are too high.
e. their size is too small.

*ANSWER:* d

10. An element, E, has the electronic configuration [Ne] $3s^2 3p^1$. Write the formula of its compound with sulfate.

*ANSWER:* $E_2(SO_4)_3$

11. Predict the electronic configuration in the oxide ion in CaO.

a. [He]$2s^2 2p^6$ or [Ne]
b. [He]$2s^2 2p^5$
c. [He]$2s^2 2p^6 3s^2$
d. [Ne]$3s^1 3p^3$
e. [Ne]$3s^2 3p^3$

*ANSWER:* a

12. Write the formula of magnesium phosphide.

*ANSWER:* $Mg_3P_2$

13. Which of the following metal ions has the ground-state electron configuration [Ar]$3d^6$?

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a. $Ca^{2+}$
b. $Cu^{+}$
c. $Fe^{2+}$
d. $Mn^{2+}$
e. $Ni^{3+}$

*ANSWER:* c

14. For the ground-state ion $Pb^{2+}$, what type of orbital do the electrons with highest energy reside in?

a. 4f
b. 5d
c. 5p
d. 6p
e. 6s

*ANSWER:* e

15. For the ground-state ion $Sn^{4+}$, what type of orbital do the electrons with highest energy reside in?

a. 4d
b. 4f
c. 4p
d. 5p
e. 5s

*ANSWER:* a

16. For the ground-state ion $Bi^{3+}$, what type of orbital do the electrons with highest energy reside in?

a. 4f
b. 5d
c. 5p
d. 6p
e. 6s

*ANSWER:* e

17. For the ground-state ion $I^{-}$, what type of orbital do the electrons with highest energy reside in?

a. 4d
b. 5d
c. 5p
d. 5s
e. 6s

*ANSWER:* c

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18. Because of the octet rule, the gaseous $O^{2-}$ ion is stable. True or false?

a. True
b. False

*ANSWER:* b

19. All the following elements exist as diatomic gases at room temperature and atmospheric pressure except

a. Ar.
b. Cl.
c. H.
d. N.
e. O.

*ANSWER:* a

20. How many lone pairs of electrons are found in the Lewis structure of the interhalogen compound $ICl_3$?

a. 10
b. 4
c. 8
d. 6
e. 7

*ANSWER:* a

21. How many lone pairs of electrons are found in the Lewis structure of urea, $(NH_2)_2CO$?

a. 2
b. 3
c. 6
d. 4
e. 8

*ANSWER:* d

22. How many lone pairs of electrons are found in the Lewis structure of hydrazine, $H_2NNH_2$?

a. 8
b. 4
c. 1
d. 0
e. 2

*ANSWER:* e

23. Draw the Lewis structure of xenon difluoride and give the number of lone pairs electrons around the central atom.

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*ANSWER:* Three

24. Draw the Lewis structure of the format ion and indicate whether resonance forms are possible.
*ANSWER:* Two resonance forms are possible.

25. Draw the "best" Lewis structures of hydrogen azide, $HN_1N_2N_3$, and the azide ion, $N_1N_2N_3^-$. The subscripts are used for identification. For each, match the following bond lengths to the correct N–N bond. The bond lengths can be used more than once.

| | N–N bond | Bond length, pm |
|---|---|---|
| hydrogen azide | $N_1$–$N_2$ | 113 |
| | $N_2$–$N_3$ | 116 |
| azide ion | $N_1$–$N_2$ | 124 |
| | $N_2$–$N_3$ | |

*ANSWER:* hydrogen azide: $N_1$–$N_2$, 124 pm; $N_2$–$N_3$, 113 pm; azide ion: $N_1$–$N_2$, 116 pm; $N_2$–$N_3$, 116 pm

26. Which of the following do not have resonance structures?

a. $CH_3CONH^-$
b. $CH_2COCH_3^-$
c. $H_2CO$
d. All have resonance structures.

*ANSWER:* c

27. For dinitrogen monoxide, the arrangement of the atoms is N-N-O. In the Lewis structure with a double bond between NN and NO, the formal charges on N, N, and O, respectively, are

a. 0, –1, +1.
b. –1, +1, 0.
c. 0, +1, –1.
d. 0, 0, 0.
e. –2, +1, +1.

*ANSWER:* b

28. For dinitrogen monoxide, the arrangement of the atoms is N-N-O. In the Lewis structure with a single bond between NN and a triple bond between NO, the formal charges on N, N, and O, respectively, are

a. –1, +1, 0.
b. 0, 0, 0.
c. 0, +1, –1.
d. 0, –1, +1.
e. –2, +1, +1.

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*ANSWER:* e

29. In the "best" Lewis structure of $XeO_4$, there are two double bonds and the formal charge on Xe is zero. True or false?

a. True
b. False

*ANSWER:* b

30. Write three Lewis structures for the cyanate ion, $NCO^-$, where the arrangement of atoms is N-C-O. In the most plausible structure,

a. the formal charge on N is –1.
b. the formal charge on O is +1.
c. there are two double bonds.
d. there is a triple bond between C and O.
e. there is a triple bond between N and C.

*ANSWER:* e

31. Predict the N-O bond lengths in $NO_2^-$, given the N-O and N=O bond lengths of 140 and 120 pm, respectively.

*ANSWER:* Both ~ 130 pm

32. Why are the N-O bond lengths in $NO_3^-$ the same?

*ANSWER:* The explanation is resonance.

33. Which of the following species are radicals?

a. $CO_2$
b. $HNO_3$
c. $NO_2$
d. $NO_3^-$
e. $HNO_3$

*ANSWER:* c

34. Which of the following species are radicals?

a. $CH_2O$
b. $ClO$
c. $ClONO_2$
d. $HClO$
e. $HCN$

*ANSWER:* b

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35. In the most plausible Lewis structure of $XeOF_2$, there are
    a. 2 single bonds, 1 double bond, and 1 lone pair of electrons around Xe.
    b. 3 single bonds and 1 lone pair of electrons around Xe.
    c. 2 single bonds, 1 double bond, and 3 lone pairs of electrons around Xe.
    d. 2 single bonds, 1 double bond, and 2 lone pairs of electrons around Xe.
    e. 3 single bonds and 2 lone pairs of electrons around Xe.

*ANSWER:* d

36. How many electrons are in the expanded valence in $XeOF_2$?
    a. 14
    b. 12
    c. 8
    d. 10
    e. 6

*ANSWER:* b

37. How many electrons are in the expanded valence in $I_3^-$?
    a. 12
    b. 6
    c. 10
    d. 14
    e. 8

*ANSWER:* c

38. How many electrons are in the expanded valence in $H_2SO_4$?
    a. 12
    b. 14
    c. 8
    d. 6
    e. 10

*ANSWER:* a

39. How many electrons are in the expanded valence in $XeO_4$?

*ANSWER:* 16

40. Consider the following equilibrium:
$S_2O_4^{2-}(aq) \rightleftharpoons 2SO_2^-(aq)$ $K \sim 10^{-9}$
Write a Lewis structure for each species.

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*ANSWER:* The arrangement of atoms in $S_2O_4^{2-}$ is $O_2S—SO_2$. The latter has a Lewis structure that obeys the octet rule, but $SO_2^-$ is a radical.

41. Which of the following species has bonds with the most ionic character?

a. $CO_2$
b. $NO_2$
c. $PCl_3$
d. $P_4O_{10}$
e. $SiO_2$

*ANSWER:* e

42. Write all possible Lewis structures of sulfur dioxide. Which structure is most feasible?

*ANSWER:* The structure with the expanded valence is favored.

43. Which of the following species has bonds with the most ionic character?

a. $CO_2$
b. $NO_2$
c. $PCl_3$
d. $P_4O_{10}$
e. $SnO_2$

*ANSWER:* e

44. Which of the following statements is true?

a. Atoms with high ionization energies and high electron affinities are highly electronegative.
b. Atoms with high ionization energies and high electron affinities have low electronegativities.
c. The electronegativity of an atom depends only on the value of the ionization energy of the atom.
d. Atoms with low ionization energies and low electron affinities have high electronegativities.
e. The electronegativity of an atom is defined as half the electron affinity of the atom.

*ANSWER:* a

45. Which of the following statements is true?

a. The electronegativity of an atom is defined as electron affinity of the atom.
b. The electronegativity of an atom depends only on the value of the ionization energy of the atom.
c. Atoms with high ionization energies and high electron affinities have low electronegativities.
d. Atoms with low ionization energies and low electron affinities have low electronegativities.
e. Atoms with low ionization energies and low electron affinities have high electronegativities.

*ANSWER:* d

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46. Which of the compounds below has bonds with the least covalent character?

a. $AgCl$
b. $AgF$
c. $AgI$
d. $AlCl_3$
e. $BeCl_2$

*ANSWER:* b

47. Which of the compounds below has bonds with the most covalent character?

a. $BeCl_2$
b. $CaCl_2$
c. $LiCl$
d. $MgCl_2$
e. $NaCl$

*ANSWER:* a

48. Which of the compounds below has bonds with the most covalent character?

a. $CaO$
b. $CaS$
c. $Li_2O$
d. $MgO$
e. $MgS$

*ANSWER:* e

49. Use the bond enthalpies given to estimate the heat released when 1-bromobutene, $CH_3CH_2CH{=}CH_2$, reacts with bromine to give $CH_3CH_2CHBrCH_2Br$. Bond enthalpies ($kJ{\cdot}mol^{-1}$): C-H, 412; C-C, 348; C=C, 612; C-Br, 276; Br-Br, 193.

a. $181\ kJ{\cdot}mol^{-1}$
b. $317\ kJ{\cdot}mol^{-1}$
c. $288\ kJ{\cdot}mol^{-1}$
d. $95\ kJ{\cdot}mol^{-1}$
e. $507\ kJ{\cdot}mol^{-1}$

*ANSWER:* d

50. Use the bond enthalpies given to estimate the heat released when ethene, $CH_2{=}CH_2$, reacts with HBr to give $CH_3CH_2Br$. Bond enthalpies ($kJ{\cdot}mol^{-1}$): C-H, 412; C-C, 348; C=C, 612; C-Br, 276; Br-Br, 193; H-Br, 366.

a. $1036\ kJ{\cdot}mol^{-1}$

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b. 200 $kJ \cdot mol^{-1}$

c. 470 $kJ \cdot mol^{-1}$

d. 424 $kJ \cdot mol^{-1}$

e. 58 $kJ \cdot mol^{-1}$

*ANSWER:* e

51. Use the bond enthalpies given to estimate the heat released when 2-methyl-1-propene, $(CH_3)_2C=CH_2$, reacts with HBr to give $(CH_3)_2CBrCH_3$. Bond enthalpies ($kJ \cdot mol^{-1}$):
C-H, 412; C-C, 348; C=C, 612; C-Br, 276; H-Br, 366.

a. 58 $kJ \cdot mol^{-1}$

b. 507 $kJ \cdot mol^{-1}$

c. 317 $kJ \cdot mol^{-1}$

d. 288 $kJ \cdot mol^{-1}$

e. 181 $kJ \cdot mol^{-1}$

*ANSWER:* a

52. Use the bond enthalpies given to estimate the heat released when ethene, $CH_2=CH_2$, reacts with hydrogen to give $CH_3CH_3$. Bond enthalpies ($kJ \cdot mol^{-1}$): C-H, 412; C-C, 348; C=C, 612; C-Br, 276; H-H, 436.

a. 124 $kJ \cdot mol^{-1}$

b. 342 $kJ \cdot mol^{-1}$

c. 288 $kJ \cdot mol^{-1}$

d. 148 $kJ \cdot mol^{-1}$

e. 560 $kJ \cdot mol^{-1}$

*ANSWER:* a

53. Which of the following compounds contains the weakest bonds to hydrogen?

a. $CH_4$

b. HF

c. $H_2O$

d. $H_2S$

e. $SiH_4$

*ANSWER:* e

54. Which of the following compounds contains the strongest bonds to hydrogen?

a. $CH_4$

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b. $HF$
c. $H_2O$
d. $H_2S$
e. $SiH_4$

*ANSWER:* b

55. Which of the following compounds is the least stable?

a. $CH_4$
b. $GeH_4$
c. $PbH_4$
d. $SiH_4$
e. $SnH_4$

*ANSWER:* c

56. Estimate the CO bond length in acetone, $CH_3COCH_3$. Given: covalent radii (pm) of C–, 77; C=, 67; O–, 74; O=, 60; H, 37.

a. 75.5 pm
b. 127 pm
c. 63.5 pm
d. 151 pm
e. 137 pm

*ANSWER:* b

57. Estimate the CN bond length in urea, $NH_2CONH_2$. Given: covalent radii (pm) of C–, 77; C=, 67; N–, 75; N=, 60; O–, 74; O=, 60; H, 37.

a. 71 pm
b. 127 pm
c. 76 pm
d. 152 pm
e. 142 pm

*ANSWER:* d

58. If the following all crystallize in the same type of structure, which has the highest lattice energy?

a. KBr
b. KCl
c. KF
d. LiCl
e. LiF

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*ANSWER:* e

59. If the following all crystallize in the same type of structure, which has the highest lattice energy?

a. KF
b. NaBr
c. NaCl
d. NaF
e. NaI

*ANSWER:* d

60. If the following all crystallize in the same type of structure, which has the lowest lattice energy?

a. BaO
b. BaS
c. CaO
d. SrO
e. SrS

*ANSWER:* b

61. If the following all crystallize in the same type of structure, which has the lowest lattice energy?

a. KCl
b. KI
c. LiCl
d. NaCl
e. NaI

*ANSWER:* b

62. White phosphorus is composed of tetrahedral molecules of $P_4$ in which every P atom is connected to three other P atoms. In the Lewis structure of $P_4$, there are

a. 3 bonding pairs and 4 lone pairs of electrons.
b. 6 bonding pairs and 2 lone pairs of electrons.
c. 5 bonding pairs and 4 lone pairs of electrons.
d. 6 bonding pairs and no lone pairs of electrons.
e. 6 bonding pairs and 4 lone pairs of electrons.

*ANSWER:* e

63. Which of the following is a radical?

a. $BF_4^-$
b. BrO
c. $CH_3^+$

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d. $CH_3^-$

*ANSWER:* b

64. If dinitrogen oxide has a dipole moment, what is the arrangement of atoms?
*ANSWER:* N-N-O

65. The electronegativity of an element can be expressed as $\frac{1}{2}(I + E_a)$ where I is the ionization energy and $E_a$ is the electron affinity. True or false?

a. True
b. False

*ANSWER:* a

66. The best Lewis structures of $SO_2$ and $O_3$ include expanded valence structures such as O=S=O and O=O=O. True or false?

a. True
b. False

*ANSWER:* b

67. Which of the following has resonance structures?

a. $XeOF_2$
b. $N_2H_4$
c. $CH_3CONH^-$
d. $H_2CO$

*ANSWER:* c

68. How many resonance structures can be drawn for $N_2O$?

a. 0
b. 3
c. 2
d. 1

*ANSWER:* b

69. What is the formal charge on the Xe atom in $XeF_4$?

a. 0
b. –4
c. +2
d. +4

*ANSWER:* a

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70. There are three resonance structures of the sulfate ion. A resonance structure can be written where the formal charge on sulfur is 0. True or false?

a. True
b. False

*ANSWER:* a

71. How many double bonds are present in the "best" resonance structure of the phosphate ion?

a. 2
b. 3
c. 1
d. 0

*ANSWER:* c

72. How many lone pairs of electrons are there in the Lewis structure of $Al_2Cl_6$?

a. 24
b. 12
c. 4
d. 16

*ANSWER:* d

73. Match each of the following compounds with its lattice energy (2961, 1046, 759, 645 kJ/mol).

KI _____
LiF _____
$MgF_2$ _____
LiI _____

*ANSWER:* KI (645 kJ/mol), LiF (1046), $MgF_2$ (2961), LiI (759)

74. White phosphorus is composed of tetrahedral molecules of $P_4$ in which each P atom is bonded to three others. In this molecule the formal charge on each P atom is _____.

*ANSWER:* 0

75. Of the following molecules, which has the strongest bonds?

a. $H_2O$
b. $H_2S$
c. $H_2Se$
d. $H_2Te$

*ANSWER:* a

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76. An element E has the electronic configuration $1s^2 2s^2 2p^4$. What is the formula of its compound with lithium?

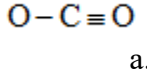
a. $LiE_2$
b. LiE
c. $Li_2E$
d. $Li_4E$

*ANSWER:* c

77. How many valence electrons are present in $W^{4+}$?

*ANSWER:* 2

78. What is wrong with the following Lewis structure?



a. The charge on the carbon atom
b. The dipole of the molecule
c. The distribution of valence electrons
d. The positioning of the carbon atom
e. The valence electron count

*ANSWER:* c

79. Sulfur is more electronegative than oxygen. True or false?

a. True
b. False

*ANSWER:* b

80. What is the electronic configuration of Ag?

*ANSWER:* $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^1\ 4d^{10}$

81. What is the formal charge of S in the molecule $H_2SO_4$?

*ANSWER:* 0

82. Why is the bond dissociation energy of C—C greater than that of C—H?

a. Because multiple bonds are always stronger than single bonds
b. Because the bond is electrostatically stronger
c. Because of the decreased bond dipole
d. Because of enhanced sigma bond overlap
e. It isn't, the dissociation energy is greater for C—H

*ANSWER:* e

83. List the chalcogens in order of increasing electronegativity.

*ANSWER:* tellurium < selenium < sulfur < oxygen.

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84. Which has the greater ionic character: $H_2S$ or $H_2O$?
*ANSWER:* $H_2O$

85. Name all the angles in a trigonal bipyramidal geometry.
*ANSWER:* 90°, 120°, and 180°

86. Name all the angles in a trigonal planar geometry.
*ANSWER:* 120°

87. Predict the HNH bond angle in $NH_2^-$.
*ANSWER:* ~109°

88. Predict the electron arrangement in $NO_2^-$.
*ANSWER:* trigonal planar

89. The electron arrangement and shape in $IF_4^+$, respectively, are
*ANSWER:* trigonal bipyramidal; seesaw.

90. Predict the electron arrangement in $ClF_3$.
*ANSWER:* Trigonal bipyramidal

91. Predict the electron arrangement in $IF_5$.
*ANSWER:* Octahedral

92. What is the shape of $AlH_4^-$?
a. Seesaw
b. Square planar
c. T-shaped
d. Tetrahedral
e. Trigonal bipyramidal
*ANSWER:* d

93. What is the shape of $BrO_4^-$?
a. Seesaw
b. Square planar
c. T-shaped
d. Tetrahedral
e. Trigonal bipyramidal
*ANSWER:* d

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94. What is the shape of $AsF_3$?

a. T-shaped
b. Trigonal planar
c. Trigonal pyramidal
d. Tetrahedral
e. Seesaw

*ANSWER:* c

95. What is the shape of $SO_3^{2-}$?

a. Seesaw
b. T-shaped
c. Tetrahedral
d. Trigonal planar
e. Trigonal pyramidal

*ANSWER:* e

96. What is the shape of $CS_3^{2-}$?

a. Trigonal pyramidal
b. Trigonal planar
c. T-shaped
d. Tetrahedral
e. Seesaw

*ANSWER:* b

97. What is the shape of $COCl_2$?

a. T-shaped
b. Trigonal planar
c. Trigonal pyramidal
d. Tetrahedral
e. Seesaw

*ANSWER:* b

98. What is the shape of $XeF_4$?

a. Seesaw
b. Square planar
c. T-Shaped
d. Tetrahedral
e. Trigonal bipyramidal

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*ANSWER:* b

99. What is the shape of $ICl_4^-$?

a. Seesaw
b. Square planar
c. T-Shaped
d. Tetrahedral
e. Trigonal bipyramidal

*ANSWER:* b

100. What is the shape of $IF_4^+$?

a. Seesaw
b. Square planar
c. T-shaped
d. Tetrahedral
e. Trigonal bipyramidal

*ANSWER:* a

101. What is the shape of $ClF_3$?

a. Seesaw
b. Square planar
c. T-shaped
d. Tetrahedral
e. Trigonal bipyramidal

*ANSWER:* c

102. All the following have a linear shape except

a. $BeCl_2$.
b. $CS_2$.
c. $I_3^-$.
d. $O_3$.
e. $XeF_2$.

*ANSWER:* d

103. All the following have an angular shape except

a. $ClO_2^-$.
b. HOCl.
c. $I_3^-$.

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d. $NH_2^-$.

e. $S_3^{2-}$.

*ANSWER:* c

104. All the following have a linear shape except

a. $CS_2$.

b. $I_3^-$.

c. $I_3^+$.

d. $IF_2^-$.

e. $XeF_2$.

*ANSWER:* c

105. All the following have an angular shape except

a. $ClO_2^-$.

b. HOCl.

c. $N_3^-$.

d. $NH_2^-$.

e. $S_3^{2-}$.

*ANSWER:* c

106. Which of the following has bond angles slightly less than 109°?

a. $BH_4^-$

b. $BrO_3^-$

c. $ClO_4^-$

d. $NH_4^+$

e. $PO_4^{3-}$

*ANSWER:* b

107. Which of the following has bond angles of 180°?

a. $ClO_2^-$

b. $HO_2^-$

c. $I_3^-$

d. $NH_2^-$

e. $O_3$

*ANSWER:* c

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108. Which of the following has bond angles of 180°?

a. $ClO_2^-$
b. $HO_2^-$
c. $NH_2^-$
d. $N_2O$
e. $O_3$

*ANSWER:* d

109. Which of the following has bond angles slightly less than 120°?

a. $I_3^-$
b. $NO_3^-$
c. $O_3$
d. $SF_2$
e. $SO_3$

*ANSWER:* c

110. Which of the following has bond angles slightly less than 109°?

a. $CH_2^-$
b. HOCl
c. $I_3^-$
d. $NO_2^-$
e. $O_3$

*ANSWER:* b

111. Which of the following has bond angles slightly less than 109°?

a. $AsF_3$
b. $COCl_2$
c. COS
d. $CS_3^{2-}$
e. $SO_2$

*ANSWER:* a

112. Which of the following has bond angles slightly less than 120°?

a. $CS_3^{2-}$
b. $HO_2^-$

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c. $I_3^+$

d. $NO_2^-$

e. $NO_3^-$

*ANSWER:* d

113. Which of the following has bond angles of 120°?

a. $CS_3^{2-}$

b. $HO_2^-$

c. $NO_2^-$

d. $O_3$

e. $S_3^{2-}$

*ANSWER:* a

114. Which of the following has bond angles of 90°, 120°, and 180°?

a. $ICl_4^-$

b. $IF_5$

c. $PF_6^-$

d. $SF_4$

e. $XeF_4$

*ANSWER:* d

115. Which of the following only has bond angles of 90°?

a. $IF_5$

b. $IF_4^+$

c. $IO_2F_3$

d. $SF_4$

e. $XeF_2$

*ANSWER:* a

116. Which of the following only has bond angles of 90° and 180°?

a. $BCl_3$

b. $BrF_3$

c. $ICl_4^+$

d. $IF_5$

e. $NO_3^-$

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*ANSWER:* b

117. Which of the following is polar?

a. $CO_3^{2-}$
b. $I_3^-$
c. NON
d. $O_3$
e. $XeF_2$

*ANSWER:* d

118. Which of the following is polar?

a. $I_3^-$
b. $ICl_4^-$
c. NON
d. $XeF_2$
e. $XeO_2$

*ANSWER:* e

119. Which of the following is polar?

a. $ICl_4^-$
b. $IF_5$
c. $PCl_5$
d. $SF_6$
e. $XeF_4$

*ANSWER:* b

120. All of the following are polar except

a. $I_3^-$.
b. $I_3^+$.
c. $NH_2^-$.
d. $O_3$.
e. $S_3^{2-}$.

*ANSWER:* a

121. All of the following are polar except

a. $ClF_3$.

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b. $ClO_2^-$.
c. $IF_4^+$.
d. $SF_4$.
e. $XeF_4$.

*ANSWER:* e

122. Which of the following is polar?

a. $AsF_6^-$
b. $ICl_4^-$
c. $SF_4$
d. $SF_6$
e. $XeF_4$

*ANSWER:* c

123. All the following are polar except

a. $BO_3^{3-}$.
b. $BrO_3^-$.
c. $ClF_3$.
d. $COCl_2$.
e. $O_3$.

*ANSWER:* a

124. All of the following are polar except

a. $BrO_3^-$.
b. $ClF_3$.
c. $COCl_2$.
d. $CS_3^{2-}$.
e. $O_3$.

*ANSWER:* d

125. All of the following are polar except

a. $ClF_3$.
b. $SOCl_2$.
c. $XeF_4$.
d. $XeO_2$.

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e. $XeO_3$.

*ANSWER:* c

126. The molecule *cis*-dichloroethene is nonpolar. True or false?

a. True
b. False

*ANSWER:* b

127. How many σ- and π-bonds, respectively, are there in acrolein, $CH_2$=CHCHO?

a. 4 and 2
b. 7 and 2
c. 5 and 2
d. 5 and 4
e. 7 and 1

*ANSWER:* b

128. How many σ- and π-bonds, respectively, are there in peroxyacetylnitrate, $CH_3C(O)O\text{-}ONO_2$?

a. 9 and 2
b. 10 and 2
c. 10 and 1
d. 8 and 4
e. 8 and 2

*ANSWER:* b

129. How many σ- and π-bonds are present in diazomethane, $CH_2NN$?

*ANSWER:* 4 σ-bonds and 2 π-bonds

130. Draw the Lewis structure of formamide, $NH_2CHO$, and give the number of lone pairs of electrons, and the number of σ- and π-bonds.

*ANSWER:* 3 lone pairs, 5 σ-bonds, and 1 π-bond

131. Draw the Lewis structure of the cyanamide ion, $NCNH^-$, and give the number of lone pairs of electrons and the number of σ- and π-bonds.

*ANSWER:* 3 lone pairs, 3 σ-bonds, and 2 π-bonds

132. Identify the hybrid orbitals used by the underlined atom in acetone, $CH_3\underline{C}OCH_3$.

a. sp
b. $sp^2$
c. $sp^3$

d. $sp^3d$

e. None; pure $p_z$-orbitals are used in bonding.

*ANSWER:* b

133. The hybrid orbitals used by the underlined atoms in $CH_3\underline{C}HCH\underline{C}N$, from left to right, respectively, are

a. $sp^3$ and sp.

b. $sp^2$ and sp.

c. $sp^2$ and $sp^3$.

d. $sp^2$ and $sp^2$.

e. sp and $sp^3$.

*ANSWER:* b

134. The hybrid orbitals used by the underlined atoms in $CH_3\underline{C}H_2\underline{O}CH_2CH_3$, from left to right, respectively, are

a. sp and sp.

b. $sp^3$ and sp.

c. $sp^3$ and $sp^3$.

d. sp and $sp^3$.

e. $sp^2$ and $sp^3$.

*ANSWER:* c

135. The hybrid orbitals used by the underlined atoms in $\underline{C}H_2CH\underline{C}HO$, from left to right, respectively, are

a. $sp^3$ and $sp^2$.

b. $sp^2$ and $sp^2$.

c. $sp^2$ and sp.

d. sp and sp.

e. $sp^3$ and sp.

*ANSWER:* b

136. For the Lewis structure of the cyanamide ion that contains two double bonds, $\underline{N}=C=NH^-$, the hybrid orbitals used by the underlined nitrogen atom and the carbon atom, respectively, are

a. $sp^2$ and $sp^3$.

b. sp and sp.

c. $sp^2$ and $sp^2$.

d. sp and $sp^3$.

e. $sp^2$ and sp.

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*ANSWER:* e

137. The NCO bond angle in formamide, $H_2NCHO$, is _____.
*ANSWER:* ~ 120° (120° is an acceptable answer)

138. All the following are paramagnetic except
a. $N_2^{2-}$.
b. $N_2^{2+}$.
c. $O_2^{-}$.
d. $O_2^{+}$.
e. $O_2$.

*ANSWER:* b

139. Which of the following is diamagnetic?
a. $O_2^{2-}$
b. $O_2^{+}$
c. $O_2^{-}$
d. $S_2$

*ANSWER:* a

140. What is the ground-state electron configuration of $O_2^{-}$?
*ANSWER:* $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p}^*)^2(\pi_{2p}^*)^1$

141. Which of the following is paramagnetic?
a. $B_2^{2-}$
b. $B_2$
c. $C_2^{2-}$
d. $N_2$
e. $O_2^{2-}$

*ANSWER:* b

142. Which of the following would have the longest bond?
a. $B_2$
b. $C_2$
c. $C_2^{2-}$
d. $N_2$

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e. $N_2^{2-}$

*ANSWER:* a

143. The bond order of $N_2^{2+}$ is

a. 2.5.
b. 1.
c. 2.
d. 1.5.
e. 3.

*ANSWER:* c

144. The bond order of $O_2^{2+}$ is

a. 1.
b. 2.
c. 3.
d. 2.5.
e. 1.5.

*ANSWER:* d

145. Which of the following has the longest bond?

a. $N_2$
b. $N_2^{2+}$
c. $N_2^{2-}$
d. $NO^-$
e. $O_2^{2-}$

*ANSWER:* e

146. Which of the following is paramagnetic?

a. $N_2$
b. $N_2^{2+}$
c. $N_2^{2-}$
d. $NO^+$
e. $O_2^{2-}$

*ANSWER:* c

147. Which of the following species has the shortest bond length?

a. $NO^{2-}$

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b. $NO^{2+}$
c. $NO^{-}$
d. NO
e. $NO^{+}$

*ANSWER:* e

148. Which of the following species has two unpaired electrons?
a. $CF^{+}$
b. $CO^{+}$
c. $NF^{+}$
d. $NO^{+}$
e. $OF^{+}$

*ANSWER:* e

149. Which of the following is a p-type semiconductor?
a. GaAs with arsenic in excess of gallium
b. Germanium doped with arsenic
c. Selenium doped with indium
d. Silicon doped with arsenic
e. Silicon doped with phosphorus

*ANSWER:* c

150. Which of the following is an n-type semiconductor?
a. GaAs with gallium in excess of arsenic
b. Germanium doped with indium
c. Selenium doped with indium
d. Silicon doped with boron
e. Silicon doped with phosphorus

*ANSWER:* e

151. Germanium is a semiconductor. Which of the following should be added in small amounts to produce a p-type semiconductor?
a. As
b. B
c. Bi
d. P
e. Sb

*ANSWER:* b

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152. Gallium is a semiconductor. Which of the following should be added in small amounts to produce a p-type semiconductor?

a. As
b. B
c. P
d. Sb
e. Si

*ANSWER:* b

153. How many lone pairs of electrons are there in the Lewis structure of azidocarbonamide, $H_2NC(O)NNC(O)NH_2$?

a. 8
b. 12
c. 10
d. 16
e. 6

*ANSWER:* a

154. What is the approximate **NNC** bond angle in azidocarbonamide, $H_2NC(O)$**NNC**$(O)NH_2$?

a. 118°
b. 180°
c. 90°
d. 107°
e. 109°

*ANSWER:* a

155. What is the hybridization of the bolded atoms **NNC,** from left to right, in azidocarbonamide, $H_2NC(O)$**NNC**$(O)NH_2$?

a. $sp^3$, sp, $sp^2$
b. $sp^2$, sp, $sp^3$
c. $sp^2$, sp, $sp^2$
d. sp, sp, $sp^2$
e. $sp^2$, $sp^2$, $sp^2$

*ANSWER:* e

156. How many σ- and π-bonds, respectively, are there in the Lewis structure of azidocarbonamide, $H_2NC(O)NNC(O)NH_2$?

a. 14 and 3
b. 15 and 3

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c. 14 and 2
d. 8 and 3
e. 11 and 3

*ANSWER:* e

157. Two Lewis structures can be written for diazomethane, where the arrangement of atoms is $H_2$**C**-**N**-N. The hybrid orbitals used by the bold atoms in these Lewis structures are

a. $sp^3$ or $sp^2$, and sp.
b. $sp^2$ and sp.
c. $sp^3$ and sp.
d. $sp^3$ or $sp^2$, and $sp^2$.

*ANSWER:* a

158. The fact that $B_2$ has two unpaired electrons means the $2p_\pi$ molecular orbitals have higher energy than the $2p_\sigma$ molecular orbitals. True or false?

a. True
b. False

*ANSWER:* b

159. How many peaks would you predict for the photoelectron spectrum of water using 1) the molecular orbital model and 2) the VSEPR model?

*ANSWER:* molecular orbital, 4; VSEPR, 2; the experimental result is 4 peaks

160. The OSO bond angle in the sulfite ion is _____ (greater than/equal to/ less than) 109.5°.

*ANSWER:* less than

161. An $AX_3E_2$ molecule has a trigonal planar shape. True or false?

a. True
b. False

*ANSWER:* b

162. Which of the following molecules is (are) polar?

(a) $AsCl_4^+$ (b) $I_3^+$ (c) $I_3^-$ (d) $N_3^-$ (e) $S_3^{2-}$

a. (b) and (e)
b. (b) and (c)
c. (c) and (e)
d. only (e)

*ANSWER:* a

163. What is the bond order in the OH radical?

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*ANSWER:* 0.5

164. When two atoms are brought together along the *x*-axis, what is the number of σ bonds that can be formed by overlap of p-orbitals on each atom?

a. 0
b. 1
c. 2
d. 3

*ANSWER:* b

165. What hybrid orbitals are used by the N atoms in urea, $H_2NCONH_2$?

a. sp
b. $sp^2$
c. $sp^3$
d. $dsp^3$

*ANSWER:* c

166. In the NO molecule, which atom makes the larger contribution to the lowest energy molecular orbital?
*ANSWER:* O

167. For $A_2$, the LCAO-MO, $\psi = c_A\psi_A + c_B\psi_B$, has $c_A = c_B$. True or false?

a. True
b. False

*ANSWER:* a

168. For HF, the LCAO-MO, $\psi = c_H\psi_H + c_F\psi_F$, has $c_H = c_F$. True or false?

a. True
b. False

*ANSWER:* b

169. For peroxyacetylnitrate, $CH_3C(O)\mathbf{O}—ONO_2$, what hybrid orbitals are used by the oxygen atom in bold?

a. dsp
b. sp
c. $sp^2$
d. $sp^3$

*ANSWER:* d

170. The molecules $OF_2$ and $O_3$ both have bent shapes. What are the approximate bond angles in $OF_2$ and $O_3$, respectively?

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a. $109^o$ and $120^o$
b. Both $109^o$
c. Both $120^o$
d. Both $180^o$
e. $109^o$ and $180^o$

*ANSWER:* a

171. What are the electron arrangements around the central atom and the shape, respectively, of $SF_4$?
a. Both square pyramidal
b. Both tetrahedral
c. Octahedral and square pyramidal
d. Seesaw
e. Trigonal bipyramidal and seesaw

*ANSWER:* e

172. What is the shape of the molecule $AX_4E_2$?
a. Octahedral
b. Seesaw
c. Square planar
d. Square pyramidal
e. Tetrahedral

*ANSWER:* c

173. The molecules $OF_2$ and $O_3$ both have bent shapes. What is the hybridization of the central atom in $OF_2$ and $O_3$, respectively?
a. $sp^3$ and $sp^2$
b. both $sp^3$
c. both $sp^2$
d. $sp^3$ and sp
e. both sp

*ANSWER:* a

174. Dinitrogen monoxide has a dipole moment. Draw the arrangement of atoms and indicate the shape of dinitrogen monoxide.
*ANSWER:* N-N-O; linear

175. The structure of Tylenol is given below:

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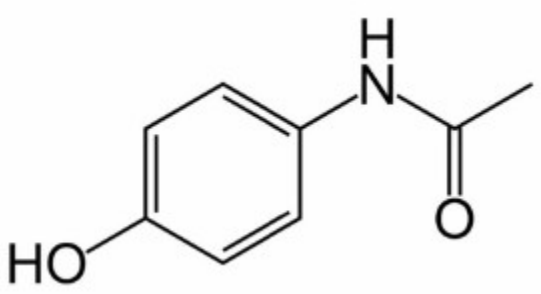
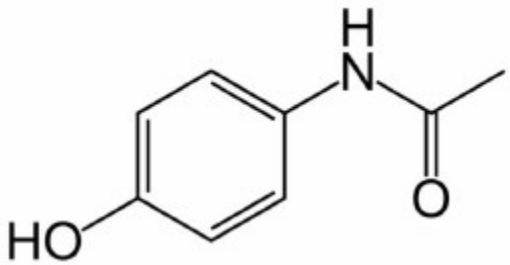



Estimate the C-N-H bond angle.

a. $\sim 109^{o}$
b. $\sim 120^{o}$
c. $> 109^{o}$
d. $> 120^{o}$
e. $\sim 90^{o}$

*ANSWER:* a

176. The structure of Tylenol is given below:




What hybrid orbitals are used on the N atom and the carbonyl carbon, respectively?

a. $sp^3$ and $sp^2$
b. $sp^2$ and $sp^2$
c. $sp^3$ and $sp^3$
d. $sp^2$ and sp
e. $sp^3$ and sp

*ANSWER:* a

177. All of the following are polar except

a. $NO_2^-$.
b. $N_2O$ (N is the central atom).
c. $NO_3^-$.
d. $NO_2Cl$.
e. $SO_3^{2-}$.

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*ANSWER:* c

178. In NO, the unpaired electron occupies what type of molecular orbital?

a. $3\sigma$
b. $4\sigma^*$
c. $2\pi^*$
d. $1\pi$
e. The oxygen 2p orbital.

*ANSWER:* c

179. Both $C_2$ and $C_2^{2-}$ are diamagnetic. True or false?

a. True
b. False

*ANSWER:* a

180. What are the electron arrangements and the shape around the central atom of $SeCl_4$?

a. Both square pyramidal
b. Both tetrahedral
c. Octahedral and square pyramidal
d. Seesaw
e. Trigonal bipyramidal and seesaw

*ANSWER:* e

181. Why does the best Lewis structure for sulfuric acid ($H_2SO_4$) have the sulfur atom formally possessing five bonds?

a. It is the best expanded octet structure for the molecule.
b. It doesn't; it should possess four bonds.
c. It doesn't; it should possess six bonds.
d. This configuration gives all atoms in the molecule a formal charge of 0.

*ANSWER:* c