MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) According to VSEPR theory, if there are two electron domains on a central atom, they will be arranged such that the angle between the domains are ___________.
   A) 109°  B) 90°  C) 180°  D) 50°  E) 300°
   Page Ref: Sec. 9.2

2) The molecular geometry of the C\(_2\) molecule is _________.
   A) T-shaped  B) linear  C) tetrahedral  D) bent  E) trigonal planar
   Page Ref: Sec. 9.2

3) The electron-domain geometry of the AsF\(_6^-\) ion is octahedral. The hybrid orbitals used by the As atom for bonding are _________.
   A) sp\(^3\)d  B) sp\(^2\)  C) sp\(^3\)d\(^2\)  D) sp\(^3\)  E) sp\(^2\)d\(^2\)
   Page Ref: Sec. 9.5

4) Valence bond theory does not address the issue of _________.
   A) excited states of molecules  B) multiple bonds  C) molecular shape  D) covalent bonding  E) hybridization
   Page Ref: Sec. 9.5

5) The O=O=O bond angle in the CO\(_2^+\) ion is approximately _________.
   A) 180°  B) 109.5°  C) 90°  D) 120°  E) 60°
   Page Ref: Sec. 9.2

6) A tetraatomic molecule cannot be planar (planar = all atoms lie in the same plane) if the hybridization of the central atom is _________.
   A) sp\(^2\) only  B) sp\(^3\) only  C) sp\(^3\)d\(^2\) only  D) sp\(^2\)d and sp\(^3\)  E) sp\(^2\)d\(^2\) and sp\(^3\)
   Page Ref: Sec. 9.5
7) The bond angles marked a, b, and c in the molecule below are about ________, ________, and ________, respectively.

\[
\begin{align*}
&\text{H} \quad \text{H} \quad \text{O} \\
&\text{H} \quad \text{N} \quad \text{C} \quad \text{C} \\
&\text{H}
\end{align*}
\]

A) 109.5°, 109.5°, 120°  \\
B) 90°, 180°, 90°  \\
C) 120°, 109.5°, 120°  \\
D) 109.5°, 109.5°, 54.7°  \\
E) 109.5°, 109.5°, 109.5°

Page Ref: Sec. 9.2  
Topic:

8) The molecular geometry of the SF\textsubscript{2} molecule is ________.
   A) trigonal planar  \\
   B) linear  \\
   C) octahedral  \\
   D) tetrahedral  \\
   E) bent

Page Ref: Sec. 9.2  
Topic:

9) Using the VSEPR model, the electron–domain geometry of the central atom in NO\textsubscript{2}\textsuperscript{-} is ________.
   A) linear  \\
   B) trigonal bipyramidal  \\
   C) trigonal planar  \\
   D) octahedral  \\
   E) tetrahedral

Page Ref: Sec. 9.2  
Topic:

10) A molecular orbital can accommodate a maximum of ________ electron(s).
    A) one  \\
    B) two  \\
    C) four  \\
    D) six  \\
    E) twelve

Page Ref: Sec. 9.7  
Topic:

Consider the following species when answering the following questions:

(i) PCl\textsubscript{3}  (ii) CCl\textsubscript{4}  (iii) TeCl\textsubscript{4}  (iv) XeF\textsubscript{4}  (v) SF\textsubscript{6}

31) In which of the molecules is the central atom sp\textsuperscript{3}d\textsuperscript{2} hybridized?
   A) (i) and (ii)  \\
   B) (iii) only  \\
   C) (iii) and (iv)  \\
   D) (v) and (v)  \\
   E) (v) only

Page Ref: Sec. 9.5  
Topic:

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12) Which molecules are polar?
   A) (i) and (v)  B) (i) and (iii)  C) (ii) and (iii)  D) (iii) and (iv)  E) (iv) and (v)
   Page Ref: Sec. 9.3

13) In which of the molecules does the central atom utilize d orbitals to form hybrid orbitals?
   A) (i) and (ii)  B) (iii) only  C) (i) and (v)  D) (iii), (iv), and (v)  E) (v) only
   Page Ref: Sec. 9.5

14) Which of the molecules has a see-saw shape?
   A) (i)  B) (ii)  C) (iii)  D) (iv)  E) (v)
   Page Ref: Sec. 9.3, 9.5

15) For which of the molecules is the molecular geometry (shape) the same as the VSEPR electron domain arrangement (electron domain geometry)?
   A) (i) and (ii)  B) (i) and (ii)  C) (ii) and (v)  D) (iv) and (v)  E) (v) only
   Page Ref: Sec. 9.2

16) The hybrid orbital set used by the central atom in NOCl is ________.
    A) sp^3d^2  B) sp^2  C) sp  D) sp^3d^3  E) sp^3
    Page Ref: Sec. 9.5

17) The hybridizations of nitrogen in NF_3 and NH_3 are ________ and ________, respectively.
    A) sp^3, sp^3  B) sp^2, sp^2  C) sp, sp^2  D) sp^3, sp  E) sp^2, sp^3
    Page Ref: Sec. 9.5

18) The Lewis structure of carbon monoxide is given below. The hybridizations of the carbon and oxygen atoms in carbon monoxide are ________ and ________, respectively.
    :C≡O:
    A) sp, sp^3  B) sp^3, sp^2  C) sp^2, sp^3  D) sp^2, sp^2  E) sp, sp
    Page Ref: Sec. 56

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19) The Cl–C–Cl bond angle in the CCl₂O molecule (C is the central atom) is slightly ________.
   A) less than 109.5°
   B) greater than 109.5°
   C) greater than 120°
   D) greater than 90°
   E) less than 120°
Page Ref: Sec. 9.2
Topic:

20) There are ________ and ________ bonds in the H–C≡C–H molecule.
   A) 4 and 3
   B) 3 and 2
   C) 2 and 3
   D) 5 and 0
   E) 3 and 4
Page Ref: Sec. 9.6
Topic:

21) In the overall process of hybrid orbital formation, the purpose of promoting one or more electrons is to ________.
   A) increase the number of unpaired electrons
   B) make sure that every atomic orbital is occupied prior to hybridization
   C) increase the number of hybrid orbitals
   D) increase the number of atomic orbitals
   E) make sure that all of the electrons in atomic orbitals are unpaired prior to hybridization
Page Ref: Sec. 9.5
Topic:

22) A triatomic molecule cannot be linear if the hybridization of the central atom is ________.
   A) sp
   B) sp²
   C) sp³
   D) sp² or sp³
   E) sp³d or sp³d²
Page Ref: Sec. 9.5
Topic:

23) According to valence bond theory, which orbitals on bromine atoms overlap in the formation of the bond in Br₂?
   A) 3s
   B) 3p
   C) 4s
   D) 4p
   E) 3d
Page Ref: Sec. 9.4
Topic:

24) In counting the electron domains around the central atom in VSEPR theory, a ________ is not included.
   A) triple covalent bond
   B) nonbonding pair of electrons
   C) double covalent bond
   D) single covalent bond
   E) lone pair of electrons
Page Ref: Sec. 9.2
Topic:
25) Based on molecular orbital theory, the bond order of the N–N bond in the N₂ molecule is 
A) 0   B) 1   C) 2   D) 3   E) 5
Page Ref: Sec. 9.8
Topic:

26) In a polyatomic molecule, "localized" bonding electrons are associated with 
A) all of the σ bonds in the molecule
B) one particular atom
C) two or more σ bonds in the molecule
D) two particular atoms
E) all of the atoms in the molecule
Page Ref: Sec. 9.6
Topic:

27) The hybridization of the central atom in the XeF₄ molecule is 
A) sp²   B) sp³d   C) sp   D) sp³d²   E) sp³
Page Ref: Sec. 9.5
Topic:

28) The central Xe atom in the XeF₄ molecule has ________ unbonded electron pairs and ________ bonded electron pairs in its valence shell.
A) 4, 2   B) 2, 4   C) 4, 0   D) 4, 1   E) 1, 4
Page Ref: Sec. 9.2
Topic:

29) The blending of one σ atomic orbital and two p atomic orbitals produces 
A) three sp² hybrid orbitals
B) three sp hybrid orbitals
C) three sp³ hybrid orbitals
D) two sp³ hybrid orbitals
E) two sp² hybrid orbitals
Page Ref: Sec. 9.5
Topic:

30) A typical triple bond consists of 
A) three ionic bonds
B) two sigma and one pi bond
C) three pi bonds
D) one sigma and two pi bonds
E) three sigma bonds
Page Ref: Sec. 9.6
Topic:

31) Of the molecules below, only ________ is polar.
A) SF₅   B) CH₄   C) I₂   D) SF₆   E) AsH₃
Page Ref: Sec. 9.3
Topic:
32) The hybridization of orbitals on the central atom in a molecule is sp². The electron-domain geometry about this central atom is ________.
   A) trigonal bipyramidal
   B) octahedral
   C) trigonal planar
   D) tetrahedral
   E) linear
Page Ref: Sec. 9.5
Topic:

33) Which of the following molecules or ions will exhibit delocalized bonding?

\[
\text{NO}_2^- \quad \text{NH}_4^+ \quad \text{N}_3^-
\]

A) NH₄⁺ and N₃⁻
B) NO₂⁻ only
C) NO₂⁻, NH₄⁺, and N₃⁻
D) N₃⁻ only
E) NO₂⁻ and N₃⁻
Page Ref: Sec. 9.6
Topic:

34) Three monosulfur fluorides are observed: SF₂, SF₄, and SF₆. Of these, ________ is/are polar.
   A) SF₂ and SF₆ only
   B) SF₄ only
   C) SF₆ only
   D) SF₂, SF₄, and SF₆
   E) SF₂ only
Page Ref: Sec. 9.3
Topic:

35) A typical double bond ________.
   A) is stronger and shorter than a single bond
   B) consists of one α bond and one σ bond
   C) consists of two shared electron pairs
   D) imparts rigidity to a molecule
   E) All of the above answers are correct.
Page Ref: Sec. 9.6
Topic:

36) In order to produce sp³ hybrid orbitals, ________ s atomic orbital(s) and ________ p atomic orbital(s) must be mixed.
   A) one, two
   B) one, three
   C) two, three
   D) one, one
   E) two, two
Page Ref: Sec. 9.5
Topic:
37) An antibonding MO ________ the corresponding bonding MO.
   A) is always lower in energy than
   B) is always degenerate with
   C) is always higher in energy than
   D) can accommodate more electrons than
   E) can accommodate fewer electrons than

Page Ref: Sec. 9.8
Topic:

38) The hybrid orbitals used for bonding by the sulfur atom in the SF₄ molecule are ________ orbitals.
   A) sp          B) sp²          C) sp³          D) sp³d          E) sp³d²

Page Ref: Sec. 9.3
Topic:

39) Molecular Orbital theory correctly predicts paramagnetism of oxygen gas, O₂. This is because ________.
   A) the O–O bond distance is relatively short
   B) the bond order in O₂ can be shown to be equal to 2.
   C) there are two unpaired electrons in the MO electron configuration of O₂
   D) the energy of the σ₂⁺ MOs is higher than that of the σ₂⁻ MO
   E) there are two electrons in the bonding orbitals than in the antibonding orbitals.

Page Ref: Sec. 9.7, 9.8
Topic:

40) According to VSEPR theory, if there are five electron domains in the valence shell of an atom, they will be arranged in a(n) ________ geometry.
   A) tetrahedral
   B) trigonal bipyramidal
   C) linear
   D) trigonal planar
   E) octahedral

Page Ref: Sec. 9.2
Topic:

41) The hybridization of the central carbon in H₂C≡C─CH₂ is ________
   A) sp          B) sp²          C) sp³          D) sp³d²          E) sp³d

Page Ref: Sec. 9.6
Topic:

42) The molecular geometry of the BrO₅⁻ ion is ________
   A) T-shaped
   B) trigonal planar
   C) tetrahedral
   D) trigonal pyramidal
   E) bent

Page Ref: Sec. 9.2
Topic:

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43) Based on molecular orbital theory, there are _______ unpaired electrons in the O\textsuperscript{2+} ion.
   A) 2       B) 3       C) 0       D) 1/2       E) 1

44) The molecular geometry of the CH\textsubscript{3}Cl\textsubscript{3} molecule is ________
   A) trigonal planar
   B) tetrahedral
   C) T-shaped
   D) bent
   E) trigonal pyramidal

45) The molecular geometry of the BeCl\textsubscript{2} molecule is ________, and this molecule is ________
   A) bent, polar
   B) linear, nonpolar
   C) linear, polar
   D) bent, nonpolar
   E) trigonal planar, polar

46) The combination of two atomic orbitals results in the formation of ________ molecular orbitals.
   A) 1       B) 2       C) 3       D) 4       E) 0

47) There are _______\alpha and _______\pi bonds in the H\textsubscript{2}C=CH\textsubscript{2} molecule.
   A) 2, 2     B) 4, 2     C) 6, 2     D) 6, 4     E) 2, 6

48) Using the VSEPR model, the electron-domain geometry of the central atom in BF\textsubscript{3} is ________
   A) trigonal planar
   B) octahedral
   C) tetrahedral
   D) trigonal bipyramidal
   E) linear

49) The electron-domain geometry and molecular geometry of iodine trichloride are ________ and ________, respectively.
   A) octahedral, trigonal planar
   B) trigonal planar, trigonal planar
   C) T-shaped, trigonal planar
   D) tetrahedral, trigonal pyramidal
   E) trigonal bipyramidal, T-shaped
50) There is/are _______ π bond(s) in the molecule below.

\[
\begin{array}{c}
\text{H} & \text{H} & \text{H} & \ddots \\
\text{H} & \text{C} & \text{C} & \text{C} & \ddots \\
\text{H} & \text{C} & \text{H} & \\
\end{array}
\]

A) 0  B) 1  C) 2  D) 4  E) 16

Page Ref: Sec. 9.6
Topic:

51) In molecular orbital theory, the \( \text{\sigma}_{1s} \) orbital is _______ and the \( \text{\sigma}_{1s}^* \) orbital is _______ in the \( \text{H}_2 \) molecule.

A) filled, empty  B) filled, filled  C) filled, half-filled  D) half-filled, filled  E) empty, filled

Page Ref: Sec. 9.7
Topic:

52) Of the following, _______ appear(s) to gain mass in a magnetic field.

\[
\begin{array}{ccc}
\text{B}_2 & \text{N}_2 & \text{O}_2 \\
\end{array}
\]

A) \( \text{N}_2 \) and \( \text{O}_2 \)  B) \( \text{N}_2 \) only  C) \( \text{B}_2 \) and \( \text{O}_2 \)  D) \( \text{O}_2 \) only  E) \( \text{B}_2 \) and \( \text{N}_2 \)

Page Ref: Sec. 9.8
Topic:

53) The total number of \( \text{\pi} \) bonds in the \( \text{H} \cdots \text{C} \cdots \text{C} \cdots \text{C} \cdots \text{N} \) molecule is _______.

A) 3  B) 4  C) 6  D) 9  E) 12

Page Ref: Sec. 9.6
Topic:

54) Using the VSEPR model, the molecular geometry of the central atom in \( \text{XeF}_2 \) is _______.

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

Page Ref: Sec. 9.2
Topic:

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55) Using the VSEPR model, the molecular geometry of the central atom in PF₅ is ________.
   A) tetrahedral
   B) square planar
   C) seesaw
   D) square pyramidal
   E) trigonal bipyramidal
   Page Ref: Sec. 9.2
   Topic:

56) The molecular geometry of the CHF₃ molecule is ________, and the molecule is ________.
   A) seesaw, nonpolar
   B) tetrahedral, polar
   C) seesaw, polar
   D) trigonal pyramidal, polar
   E) tetrahedral, nonpolar
   Page Ref: Sec. 9.3
   Topic:

57) An antibonding π orbital contains a maximum of ________ electrons.
   A) 1
   B) 2
   C) 4
   D) 6
   E) 8
   Page Ref: Sec. 9.7
   Topic:

58) Based on molecular orbital theory, the only molecule in the list below that has unpaired electrons is

   A) F₂  
   B) N₂  
   C) C₂  
   D) Li₂  
   E) O₂
   Page Ref: Sec. 9.8
   Topic:

59) The hybridization of the oxygen atom labeled y in the structure below is ________. The C–O–H bond angle is ________.

   H   H
   |   | 102° ← x
   H–C≡C–C–H
   |   |    H
   H   H
   A) sp³, 109.5° 
   B) sp, 90° 
   C) sp², 109.5° 
   D) sp, 180° 
   E) sp³d², 90°
   Page Ref: Sec. 9.5
   Topic:

60) Based on molecular orbital theory, the bond order of the Be–Be bond in the Be₂ molecule is ________.

   A) 0  
   B) 1  
   C) 2  
   D) 3  
   E) 4
   Page Ref: Sec. 9.8
   Topic:

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