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Sample

Chemistry: A Molecular Approach, 2e (Tro)

**Chapter 10 Chemical Bonding II: Molecular Shapes, Valence Bond Theory,
and Molecular Orbital Theory**

Multiple Choice Questions

1) Give the approximate bond angle for a molecule with a trigonal planar shape.

- 109. A) 109.5°
- 110. B) 180°
- 111. C) 120°
- 112. D) 105°
- 113. E) 90°

Answer: C

Diff: 2 Page Ref: 10.2

2) Give the approximate bond angle for a molecule with a tetrahedral shape.

- 109. A) 109.5°
- 110. B) 180°
- 111. C) 120°
- 112. D) 105°
- 113. E) 90°

Answer: A

Diff: 2 Page Ref: 10.2

3) Give the approximate bond angle for a molecule with a linear shape.

- 109. A) 109.5°
- 110. B) 180°
- 111. C) 120°
- 112. D) 105°
- 113. E) 90°

Answer: B

Diff: 2 Page Ref: 10.2

4) Give the approximate bond angle for a molecule with an octahedral shape.

- 109. A) 109.5°
- 110. B) 180°
- 111. C) 120°
- 112. D) 105°
- 113. E) 90°

Answer: E

Diff: 2 Page Ref: 10.2

5) Determine the electron geometry (eg) and molecular geometry(mg) of BCl_3 .

- 1. A) eg=trigonal planar, mg=trigonal planar
- 2. B) eg=tetrahedral, mg=trigonal planar
- 3. C) eg=tetrahedral, mg=trigonal pyramidal
- 4. D) eg=trigonal planar, mg=bent
- 5. E) eg=trigonal bipyramidal, mg= trigonal bipyramidal

Answer: A

Diff: 2 Page Ref: 10.2

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=tetrahedral, mg=trigonal pyramidal
3. C) eg=trigonal planar, mg=bent
4. D) eg=trigonal planar, mg=trigonal planar
5. E) eg=tetrahedral, mg=trigonal planar

Answer: D

Diff: 2 Page Ref: 10.2

7) Determine the electron geometry (eg) and molecular geometry (mg) of CH_3^+ .

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=tetrahedral, mg=trigonal pyramidal
3. C) eg=trigonal planar, mg=bent
4. D) eg=trigonal planar, mg=trigonal planar
5. E) eg=tetrahedral, mg=trigonal planar

Answer: D

Diff: 2 Page Ref: 10.2

8) Determine the electron geometry (eg) and molecular geometry (mg) of SiF_4 .

1. A) eg=tetrahedral, mg=trigonal pyramidal
2. B) eg=octahedral, mg=trigonal planar
3. C) eg=trigonal bipyramidal, mg=trigonal pyramidal
4. D) eg=tetrahedral, mg=bent
5. E) eg=tetrahedral, mg=tetrahedral

Answer: E

Diff: 2 Page Ref: 10.2

9) Determine the electron geometry (eg) and molecular geometry (mg) of PF₅.

1. A) eg=trigonal bipyramidal, mg=trigonal bipyramidal
2. B) eg=octahedral, mg=octahedral
3. C) eg=trigonal bipyramidal, mg=tetrahedral
4. D) eg=tetrahedral, mg=trigonal pyramidal
5. E) eg=trigonal planar, mg=octahedral

Answer: A

Diff: 2 Page Ref: 10.2

10) Determine the electron geometry (eg) and molecular geometry (mg) of CO₂.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=trigonal planar
3. C) eg=trigonal planar, mg=bent
4. D) eg=linear, mg=linear
5. E) eg=trigonal planar, mg=trigonal planar

Answer: D

Diff: 2 Page Ref: 10.2

11) Determine the electron geometry (eg) and molecular geometry (mg) of NCl₃.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=trigonal planar
3. C) eg=trigonal planar, mg=bent
4. D) eg=linear, mg=linear
5. E) eg=tetrahedral, mg=trigonal pyramidal

Answer: E

Diff: 2 Page Ref: 10.2

12) Determine the electron geometry (eg) and molecular geometry (mg) of BrF_3 .

1. A) eg=trigonal planar, mg=trigonal planar
2. B) eg=trigonal bipyramidal, mg= T-shape
3. C) eg=trigonal planar, mg=bent
4. D) eg=trigonal bipyramidal, mg=see-saw
5. E) eg=tetrahedral, mg=trigonal pyramidal

Answer: B

Diff: 3 Page Ref: 10.4

1. A) eg=tetrahedral, mg=bent
2. B) eg=tetrahedral, mg=trigonal pyramidal
3. C) eg=trigonal bipyramidal, mg=linear
4. D) eg=trigonal bipyramidal, mg=trigonal planar
5. E) eg=octahedral, mg=linear

Answer: C

Diff: 3 Page Ref: 10.4

14) Determine the electron geometry (eg) and molecular geometry (mg) of XeF_2 .

1. A) eg=trigonal bipyramidal, mg=bent
2. B) eg=linear, mg=linear
3. C) eg=tetrahedral, mg=linear
4. D) eg=trigonal bipyramidal, mg=linear
5. E) eg=tetrahedral, mg=bent

Answer: D

Diff: 3 Page Ref: 10.4

15) Determine the electron geometry (eg) and molecular geometry (mg) of XeF₄.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=linear
3. C) eg=tetrahedral, mg=bent
4. D) eg=trigonal bipyramidal, mg=tetrahedral
5. E) eg=octahedral, mg=square planar

Answer: E

Diff: 3 Page Ref: 10.4

16) Determine the electron geometry (eg) and molecular geometry (mg) of the underlined atom CH₃OCH₃.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=linear
3. C) eg=tetrahedral, mg=bent
4. D) eg=trigonal bipyramidal, mg=tetrahedral
5. E) eg=octahedral, mg=square planar

Answer: A

Diff: 3 Page Ref: 10.4

17) Determine the electron geometry (eg) and molecular geometry (mg) of the underlined atom CH₃OCH₃.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=linear
3. C) eg=tetrahedral, mg=bent
4. D) eg=trigonal bipyramidal, mg=tetrahedral

5. E) eg=octahedral, mg=square planar

Answer: C

Diff: 3 Page Ref: 10.4

18) Consider the molecule below. Determine the molecular geometry at each of the 2 labeled carbons.

1. A) C1 = tetrahedral, C2 = linear
2. B) C1 = trigonal planar, C2 = bent
3. C) C1 = bent, C2 = trigonal planar
4. D) C1 = trigonal planar, C2 = tetrahedral
5. E) C1 = trigonal pyramidal, C2 = see-saw

Answer: D

Diff: 3 Page Ref: 10.4

19) Consider the molecule below. Determine the molecular geometry at each of the 3 labeled atoms.

1. A) 1=trigonal planar, 2=tetrahedral, 3=trigonal pyramidal
2. B) 1=tetrahedral, 2=tetrahedral, 3=tetrahedral
3. C) 1=trigonal planar, 2=tetrahedral, 3=tetrahedral
4. D) 1=tetrahedral, 2=tetrahedral, 3=trigonal planar
5. E) 1=trigonal planar, 2=trigonal pyramidal, 3=trigonal pyramidal

Answer: A

Diff: 3 Page Ref: 10.4

20) Place the following in order of **increasing** X-Se-X bond angle, where X represents the outer atoms in each molecule.

SeO₂ SeCl₆ SeF₂

1. A) SeCl₆ < SeF₂ < SeO₂
2. B) SeF₂ < SeO₂ < SeCl₆
3. C) SeF₂ < SeCl₆ < SeO₂
4. D) SeO₂ < SeF₂ < SeCl₆
5. E) SeCl₆ < SeO₂ < SeF₂

Answer: A

Diff: 4 Page Ref: 10.4

21) Place the following in order of **increasing** F-A-F bond angle, where A represents the central atom in each molecule.

PF₃ OF₂

Answer: B

Diff: 4 Page Ref: 10.4

22) Place the following in order of **decreasing** X-A-X bond angle, where A represents the central atom and X represents the outer atoms in each molecule.

N₂O NCl₃

Answer: C

Diff: 4 Page Ref: 10.4

23) Place the following in order of **decreasing** X-A-X bond angle, where A represents the central atom and X represents the outer atoms in each molecule.

CS₂ CF₄ SCl₂

1. A) CS₂ = SCl₂ > CF₄
2. B) SCl₂ > CF₄ > CS₂
3. C) CF₄ > CS₂ > SCl₂
4. D) CS₂ > CF₄ > SCl₂
5. E) CF₄ > CS₂ > SCl₂

Answer: D

Diff: 4 Page Ref: 10.4

24) Place the following in order of **increasing** X-A-X bond angle, where A represents the central atom and X represents the outer atoms in each molecule.
HCN H₂O

Answer: E

Diff: 4 Page Ref: 10.4

25) A pilot checks for water in the gas before flying a small airplane.
How does she do it?

1. A) Drain a little bit of gas from the bottom and look for two layers.
2. B) Smell it.
3. C) Shake the wings.
4. D) Pipet the liquid from the top of the tank and look for two layers.
5. E) Check the gas gauge.

Answer: A

Diff: 1 Page Ref: 10.5

26) Determine the electron geometry (eg), molecular geometry (mg), and polarity of SO₃.

1. A) eg=tetrahedral, mg=trigonal pyramidal, polar
2. B) eg=tetrahedral, mg=tetrahedral, nonpolar
3. C) eg=trigonal planar, mg=trigonal planar, nonpolar
4. D) eg= trigonal bipyramidal, mg=trigonal planar, polar
5. E) eg=trigonal pyramidal, mg=bent, nonpolar

Answer: C

Diff: 2 Page Ref: 10.5

27) How many of the following molecules are polar?

BrCl₃ CS₂ SiF₄ SO₃

1. A) 1
2. B) 2
3. C) 3
4. D) 4
5. E) 0

Answer: A

Diff: 3 Page Ref: 10.5

28) How many of the following molecules are polar?

XeCl₂ COF₂ PCl₄F SF₆

1. A) 0
2. B) 3

3. C) 1
4. D) 2
5. E) 4

Answer: B

Diff: 3 Page Ref: 10.5

29) How many of the following molecules are polar?

XeO₂ SiCl₂Br₂ C₂Br₂ SeCl₆

1. A) 1
2. B) 4
3. C) 2
4. D) 3
5. E) 0

Answer: C

Diff: 3 Page Ref: 10.5

30) How many of the following molecules are polar?

PCl₅ COS XeO₃ SeBr₂

1. A) 2
2. B) 0
3. C) 1
4. D) 3

5. E) 4

Answer: D

Diff: 3 Page Ref: 10.5

31) Determine the electron geometry (eg), molecular geometry (mg), and polarity of SO₂.

1. A) eg=tetrahedral, mg=bent, polar
2. B) eg=trigonal planar, mg=bent, polar
3. C) eg=linear, mg=linear, nonpolar
4. D) eg=tetrahedral, mg=tetrahedral, nonpolar
5. E) eg=trigonal pyramidal, mg=trigonal pyramidal, polar

Answer: B

Diff: 3 Page Ref: 10.5

32) Determine the electron geometry, molecular geometry and polarity of SF₆.

1. A) eg=trigonal bipyramidal, mg=trigonal bipyramidal, nonpolar
2. B) eg=tetrahedral, mg=tetrahedral, polar
3. C) eg=trigonal bipyramidal, mg=see-saw, polar
4. D) eg=octahedral, mg=trigonal bipyramidal, nonpolar
5. E) eg=octahedral, mg=octahedral, nonpolar

Answer: E

Diff: 3 Page Ref: 10.5

33) Determine the electron geometry, molecular geometry and polarity of TeCl₆.

1. A) eg=octahedral, mg=octahedral, nonpolar
2. B) eg=trigonal bipyramidal, mg=trigonal bipyramidal, nonpolar
3. C) eg=octahedral, mg=octahedral, polar

4. D) eg=trigonal bipyramidal, mg=see-saw, polar
5. E) eg=tetrahedral, mg=trigonal pyramidal, polar

Answer: A

Diff: 3 Page Ref: 10.5

34) Determine the electron geometry (eg), molecular geometry(mg) and polarity of XeO₃.

1. A) eg=trigonal planar, mg=trigonal planar, nonpolar
2. B) eg=tetrahedral, mg=trigonal pyramidal, polar
3. C) eg=trigonal planar, mg=trigonal pyramidal, polar
4. D) eg=trigonal bipyramidal, mg=trigonal planar, nonpolar
5. E) eg=octahedral, mg=tetrahedral, nonpolar

Answer: B

Diff: 3 Page Ref: 10.5

35) Determine the electron geometry, molecular geometry and polarity of HBrO₂ .

1. A) eg=trigonal bipyramidal, mg=trigonal planar, nonpolar
2. B) eg=octahedral, mg=trigonal planar, nonpolar
3. C) eg=tetrahedral, mg=trigonal pyramidal, polar
4. D) eg=tetrahedral, mg=linear, nonpolar
5. E) eg=linear, mg=linear, polar

Answer: C

Diff: 3 Page Ref: 10.5

36) Determine the electron geometry, molecular geometry and polarity of XeF₆ .

1. A) eg=trigonal bipyramidal, mg=trigonal bipyramidal, nonpolar
2. B) eg=tetrahedral, mg=tetrahedral, polar

3. C) eg=trigonal bipyramidal, mg=see-saw, polar
4. D) eg=octahedral, mg=trigonal bipyramidal, nonpolar
5. E) eg=octahedral, mg=octahedral, nonpolar

Answer: E

Diff: 3 Page Ref: 10.5

37) Choose the compound below that contains at least one polar covalent bond, but is nonpolar.

1. A) HCN
2. B) CF₄
3. C) SeBr₄
4. D) ICl₃
5. E) Both B and C are nonpolar and contain a polar covalent bond.

Answer: B

Diff: 3 Page Ref: 10.5

38) Choose the compound below that contains at least one polar covalent bond, but is nonpolar.

1. A) GeH₂Br₂
2. B) SCl₂
3. C) AsCl₅
4. D) CF₂Cl₂
5. E) All of the above are nonpolar and contain a polar covalent bond.

Answer: C

Diff: 3 Page Ref: 10.5

39) Place the following in order of **increasing** dipole moment.

1. BCl₃ II. BIF₂ III. BCIF₂

1. A) I < II = III
2. B) II < III < I
3. C) I < II < III
4. D) II < I < III
5. E) I < III < II

Answer: E

Diff: 3 Page Ref: 10.5

40) Place the following in order of **decreasing** dipole moment.

1. cis-CHCl=CHCl II. trans-CHCl=CHCl III. cis-CHF=CHF

1. A) III > I > II
2. B) II > I > III
3. C) I > III > II
4. D) II > III > I
5. E) I = III > II

Answer: A

Diff: 3 Page Ref: 10.5

41) Determine the electron geometry, molecular geometry and polarity of N₂O (N central).

1. A) eg=linear, mg=linear, nonpolar
2. B) eg=tetrahedral, mg=linear, nonpolar
3. C) eg=tetrahedral, mg=bent, polar

4. D) eg= linear, mg=linear, polar
5. E) eg=trigonal planar, mg=bent, polar

Answer: D

Diff: 4 Page Ref: 10.5

42) Describe a pi bond.

1. A) side by side overlap of p orbitals
2. B) end to end overlap of p orbitals
3. C) s orbital overlapping with the end of a p orbital
4. D) overlap of two s orbitals
5. E) p orbital overlapping with a d orbital

Answer: A

Diff: 1 Page Ref: 10.7

43) Describe a sigma bond.

1. A) side by side overlap of p orbitals
2. B) end to end overlap of p orbitals
3. C) s orbital overlapping with the side of a p orbital
4. D) overlap of two s orbitals
5. E) p orbital overlapping with a d orbital

Answer: B

Diff: 1 Page Ref: 10.7

44) A molecule containing a central atom with sp hybridization has a(n) _____ electron geometry.

1. A) linear
2. B) trigonal bipyramidal
3. C) trigonal planar
4. D) tetrahedral
5. E) bent

Answer: A

Diff: 1 Page Ref: 10.7

45) Identify the number of electron groups around a molecule with sp hybridization.

1. A) 1
2. B) 2
3. C) 3
4. D) 4
5. E) 5

Answer: B

Diff: 1 Page Ref: 10.7

46) A molecule containing a central atom with sp^2 hybridization has a(n) _____ electron geometry.

1. A) linear
2. B) trigonal bipyramidal
3. C) trigonal planar
4. D) tetrahedral
5. E) bent

Answer: C

Diff: 1 Page Ref: 10.7

47) Identify the number of electron groups around a molecule with sp^2 hybridization.

1. A) 1
2. B) 2
3. C) 3
4. D) 4
5. E) 5

Answer: C

Diff: 1 Page Ref: 10.7

48) A molecule containing a central atom with sp^3 hybridization has a(n) _____ electron geometry.

1. A) linear
2. B) trigonal bipyramidal
3. C) octahedral
4. D) tetrahedral
5. E) bent

Answer: D

Diff: 1 Page Ref: 10.7

49) Identify the number of electron groups around a molecule with a tetrahedral shape.

1. A) 1
2. B) 2
3. C) 3
4. D) 4
5. E) 5

Answer: D

Diff: 1 Page Ref: 10.7

50) A molecule containing a central atom with sp^3d hybridization has a(n) _____ electron geometry.

1. A) tetrahedral
2. B) linear
3. C) octahedral
4. D) trigonal planar
5. E) trigonal bipyramidal

Answer: E

Diff: 1 Page Ref: 10.7

51) Identify the number of electron groups around a molecule with a trigonal bipyramidal shape.

1. A) 1
2. B) 2
3. C) 3
4. D) 4
5. E) 5

Answer: E

Diff: 1 Page Ref: 10.7

52) A molecule containing a central atom with sp^3d^2 hybridization has a(n) _____ electron geometry.

1. A) octahedral
2. B) trigonal bipyramidal
3. C) tetrahedral
4. D) trigonal planar

5. E) trigonal pyramidal

Answer: A

Diff: 1 Page Ref: 10.7

53) Determine the electron geometry (eg) and molecular geometry (mg) of the underlined carbon in $\text{CH}_3\text{C}\underline{\text{N}}$.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=trigonal planar
3. C) eg=trigonal planar, mg=bent
4. D) eg=linear, mg=linear
5. E) eg=trigonal planar, mg=trigonal planar

Answer: D

Diff: 2 Page Ref: 10.7

54) Determine the electron geometry (eg) and molecular geometry (mg) of the underlined carbon in $\underline{\text{C}}\text{H}_3\text{CN}$.

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=trigonal planar
3. C) eg=trigonal planar, mg=bent
4. D) eg=linear, mg=linear
5. E) eg=trigonal planar, mg=trigonal planar

Answer: A

Diff: 2 Page Ref: 10.7

55) Determine the electron geometry (eg) and molecular geometry (mg) of H_2CO .

1. A) eg=tetrahedral, mg=tetrahedral
2. B) eg=linear, mg=trigonal planar
3. C) eg=trigonal planar, mg=bent
4. D) eg=linear, mg=linear

5. E) eg=trigonal planar, mg=trigonal planar

Answer: E

Diff: 2 Page Ref: 10.7

56) Draw the Lewis structure for OF₂. What is the hybridization on the O atom?

1. A) sp
2. B) sp³
3. C) sp²
4. D) sp³d
5. E) sp³d²

Answer: B

Diff: 3 Page Ref: 10.7

57) Draw the Lewis structure for H₃O⁺. What is the hybridization on the O atom?

1. A) sp
2. B) sp³
3. C) sp²
4. D) sp³d
5. E) sp³d²

Answer: B

Diff: 3 Page Ref: 10.7

58) Draw the Lewis structure for SO₃. What is the hybridization on the S atom?

1. A) sp
2. B) sp³
3. C) sp²
4. D) sp³d
5. E) sp³d²

Answer: C

Diff: 3 Page Ref: 10.7

59) Draw the Lewis structure for BrO_4^- . What is the hybridization on the Br atom?

1. A) sp
2. B) sp^3d^2
3. C) sp^3d
4. D) sp^3
5. E) sp^2

Answer: D

Diff: 3 Page Ref: 10.7

60) Draw the Lewis structure for SF_6 . What is the hybridization on the S atom?

1. A) sp
2. B) sp^2
3. C) sp^3
4. D) sp^3d
5. E) sp^3d^2

Answer: E

Diff: 3 Page Ref: 10.7

61) Draw the Lewis structure for BrF_5 . What is the hybridization on the Br atom?

1. A) sp^3d^2
2. B) sp^3d
3. C) sp^3
4. D) sp^2
5. E) sp

Answer: A

Diff: 3 Page Ref: 10.7

62) Draw the Lewis structure for BrCl_3 . What is the hybridization on the Br atom?

1. A) sp^3d^2
2. B) sp^3d
3. C) sp^3
4. D) sp^2
5. E) sp

Answer: B

Diff: 3 Page Ref: 10.7

63) Consider the molecule below. Determine the hybridization at each of the 2 labeled carbons.

1. A) $\text{C}_1 = \text{sp}^3$, $\text{C}_2 = \text{sp}^3\text{d}$
2. B) $\text{C}_1 = \text{sp}$, $\text{C}_2 = \text{sp}^2$
3. C) $\text{C}_1 = \text{sp}^2$, $\text{C}_2 = \text{sp}^3\text{d}$
4. D) $\text{C}_1 = \text{sp}^3\text{d}$, $\text{C}_2 = \text{sp}^3\text{d}^2$
5. E) $\text{C}_1 = \text{sp}^2$, $\text{C}_2 = \text{sp}^3$

Answer: E

Diff: 4 Page Ref: 10.7

64) Consider the molecule below. Determine the hybridization at each of the 3 labeled atoms.

1. A) 1=sp², 2=sp³, 3=sp²
2. B) 1=sp², 2=sp³, 3=sp³
3. C) 1=sp³, 2=sp³, 3=sp³
4. D) 1=sp³, 2=sp³, 3=sp²
5. E) 1=sp, 2=sp², 3=sp²

Answer: B

Diff: 4 Page Ref: 10.7

65) How many of the following molecules have sp hybridization on the central atom?

C₂Cl₂ CO₂ O₃ H₂O

1. A) 0
2. B) 1
3. C) 2
4. D) 3
5. E) 4

Answer: C

Diff: 4 Page Ref: 10.7

66) How many of the following molecules have sp³ hybridization on the central atom?

XeCl₄ CH₄ SF₄ C₂H₂

1. A) 0
2. B) 4
3. C) 3
4. D) 2
5. E) 1

Answer: E

Diff: 4 Page Ref: 10.7

67) How many of the following molecules have sp^3d hybridization on the central atom?

$SiCl_4$ BrF_5 AsF_5 BrF_3

1. A) 2
2. B) 0
3. C) 4
4. D) 1
5. E) 3

Answer: A

Diff: 4 Page Ref: 10.7

68) How many of the following molecules have sp^3d^2 hybridization on the central atom?

$SeCl_6$ XeF_4 IF_5 $AsCl_5$

1. A) 1
2. B) 3
3. C) 0
4. D) 2
5. E) 4

Answer: B

Diff: 4 Page Ref: 10.7

69) How many of the following molecules have sp^2 hybridization on the central atom?

HCN SO_2 OCl_2 $XeCl_2$

1. A) 4
2. B) 3
3. C) 2
4. D) 1
5. E) 0

Answer: D

Diff: 5 Page Ref: 10.7

70) Give the electron geometry, molecular geometry, and hybridization for CH_3^- .

1. A) eg = tetrahedral; mg = trigonal pyramidal; sp^3
2. B) eg = tetrahedral; mg = tetrahedral; sp^3
3. C) eg = trigonal pyramidal; mg = trigonal pyramidal; sp^3
4. D) eg = trigonal planar; mg = trigonal planar; sp^2

Answer: A

Diff: 5 Page Ref: 10.7

71) List the number of sigma bonds and pi bonds in a single bond.

1. A) 1 sigma, 0 pi
2. B) 0 sigma, 1 pi
3. C) 1 sigma, 1 pi
4. D) 1 sigma, 2 pi

Answer: A

Diff: 5 Page Ref: 10.7

72) List the number of sigma bonds and pi bonds in a double bond.

1. A) 1 sigma, 1 pi
2. B) 2 sigma, 1 pi
3. C) 2 sigma, 2 pi
4. D) 1 sigma, 2 pi

Answer: A

Diff: 5 Page Ref: 10.7

73) List the number of sigma bonds and pi bonds in a triple bond.

1. A) 1 sigma, 1 pi
2. B) 2 sigma, 1 pi
3. C) 2 sigma, 2 pi
4. D) 1 sigma, 2 pi

Answer: D

Diff: 5 Page Ref: 10.7

74) Draw the Lewis structure for the molecule CH_2CHCH_3 . How many sigma and pi bonds does it contain?

1. A) 8 sigma, 1 pi
2. B) 9 sigma, 0 pi
3. C) 9 sigma, 1 pi
4. D) 7 sigma, 2 pi
5. E) 8 sigma, 2 pi

Answer: A

Diff: 5 Page Ref: 10.7

75) Draw the Lewis structure for the molecule $\text{CH}_3\text{CH}_2\text{CCH}$. How many sigma and pi bonds does it contain?

1. A) 11 sigma, 0 pi
2. B) 9 sigma, 1 pi
3. C) 8 sigma, 3 pi
4. D) 9 sigma, 2 pi
5. E) 8 sigma, 2 pi

Answer: D

Diff: 5 Page Ref: 10.7

76) Consider the following compound. How many sigma and pi bonds does it contain?



1. A) 9 sigma, 4 pi
2. B) 11 sigma, 2 pi
3. C) 9 sigma, 2 pi
4. D) 13 sigma, 0 pi

5. E) 6 sigma, 2

pi Answer: B

Diff: 5 Page Ref: 10.7

77) Draw the Lewis structure for the molecule C_3H_4 . How many sigma and pi bonds does it contain?

1. A) 7 sigma, 1 pi
2. B) 8 sigma, 0 pi
3. C) 6 sigma, 2 pi
4. D) 10 sigma, 0 pi
5. E) 8 sigma, 2 pi

Answer: C

Diff: 5 Page Ref: 10.7

78) How many of the following molecules contain at least one pi bond?

C_2H_6 Cl_2CO C_2Cl_4 SeS_3

1. A) 0
2. B) 1
3. C) 3
4. D) 4
5. E) 2

Answer: C

Diff: 5 Page Ref: 10.7

79) Which of the following statements is TRUE?

1. A) The total number of molecular orbitals formed doesn't always equal the number of atomic orbitals in the set.
2. B) A bond order of 0 represents a stable chemical bond.
3. C) When two atomic orbitals come together to form two molecular orbitals, one molecular orbital will be lower in energy than the two separate atomic orbitals and one molecular orbital will be higher in energy than the separate atomic orbitals.
4. D) Electrons placed in antibonding orbitals stabilize the ion/molecule.
5. E) All of the above are true.

Answer: C

Diff: 3 Page Ref: 10.8

80) Use the molecular orbital diagram shown to determine which of the following is **most** stable.

1. A) F₂

Answer: D

Diff: 4 Page Ref: 10.8

81) Use the molecular orbital diagram shown to determine which of the following are paramagnetic.

1. AlO₂⁻

5. E) None of the above are paramagnetic.

Answer: D

Diff: 4 Page Ref: 10.8

82) Use the molecular orbital diagram shown to determine which of the following is **most** stable.

3. C) B₂

Answer: D

Diff: 4 Page Ref: 10.8

83) Use the molecular orbital diagram shown to determine which of the following are paramagnetic.

5. E) B₂

Answer: E

Diff: 4 Page Ref: 10.8

84) Draw the molecular orbital diagram shown to determine which of the following is **most** stable.

1. A) F₂

Answer: D

Diff: 5 Page Ref: 10.8

85) Draw the molecular orbital diagram shown to determine which of the following is paramagnetic.

5. E) None of the above are paramagnetic.

Answer: D

Diff: 5 Page Ref: 10.8

86) Draw the molecular orbital diagram shown to determine which of the following is **most** stable.

3. C) B₂

Answer: D

Diff: 5 Page Ref: 10.8

87) Draw the molecular orbital diagram shown to determine which of the following is paramagnetic.

5. E) B₂

Answer: E

Diff: 5 Page Ref: 10.8

Algorithmic Questions

1) What geometric arrangement of charge clouds is expected for an atom that has four charge clouds?

1. A) trigonal bipyramidal
2. B) octahedral
3. C) tetrahedral
4. D) square planar

Answer: C

Diff: 1 Page Ref: 10.2

2) What is the molecular geometry of ClF₄⁻?

1. A) seesaw
2. B) square planar
3. C) square pyramidal
4. D) tetrahedral

Answer: B

Diff: 3 Page Ref: 10.4

3) What is the molecular geometry of NCl_3 ?

1. A) T-shaped
2. B) tetrahedral
3. C) trigonal planar
4. D) trigonal pyramidal

Answer: D

Diff: 3 Page Ref: 10.4

4) What is the molecular geometry of SF_5^- ?

1. A) octahedral
2. B) seesaw
3. C) square pyramidal
4. D) trigonal bipyramidal

Answer: C

Diff: 3 Page Ref: 10.4

5) Which of the following best describes ClF_2^- ? It has a molecular geometry that is

1. A) linear with no lone pairs on the Cl atom.
2. B) linear with lone pairs on the Cl atom.

3. C) nonlinear with no lone pairs on the Cl atom.
4. D) nonlinear with lone pairs on the Cl atom.

Answer: B

Diff: 3 Page Ref: 10.4

6) What is the molecular geometry of TeCl₄?

1. A) seesaw
2. B) square planar
3. C) square pyramidal
4. D) tetrahedral

Answer: A

Diff: 3 Page Ref: 10.4

7) Using the VSEPR model, the electron-domain geometry of the central atom in BrF₄⁻ is _____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) trigonal bipyramidal
5. E) octahedral

Answer: E

Diff: 3 Page Ref: 10.4

8) Using the VSEPR model, the molecular geometry of the central atom in XeF₂ is _____.

1. A) linear
2. B) trigonal planar

3. C) tetrahedral
4. D) bent
5. E) trigonal pyramidal

Answer: A

Diff: 3 Page Ref: 10.4

9) Using the VSEPR model, the molecular geometry of the central atom in BF_3 is _____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) bent
5. E) trigonal pyramidal

Answer: B

Diff: 3 Page Ref: 10.4

10) Using the VSEPR model, the molecular geometry of the central atom in CF_4 is _____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) bent
5. E) trigonal pyramidal

Answer: C

Diff: 3 Page Ref: 10.4

11) Using the VSEPR model, the molecular geometry of the central atom in SO_2 is _____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) bent
5. E) trigonal pyramidal

Answer: D

Diff: 3 Page Ref: 10.4

12) Using the VSEPR model, the molecular geometry of the central atom in NCl_3 is _____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) bent
5. E) trigonal pyramidal

Answer: E

Diff: 3 Page Ref: 10.4

13) Using the VSEPR model, the molecular geometry of the central atom in XeF_4 is _____.

1. A) tetrahedral
2. B) seesaw
3. C) square planar
4. D) trigonal bipyramidal
5. E) square pyramidal

Answer: C

Diff: 3 Page Ref: 10.4

14) Using the VSEPR model, the electron-domain geometry of the central atom in BF_3 is_____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) trigonal bipyramidal
5. E) octahedral

Answer: B

Diff: 3 Page Ref: 10.4

15) Using the VSEPR model, the electron-domain geometry of the central atom in SF_2 is_____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) trigonal bipyramidal
5. E) octahedral

Answer: C

Diff: 3 Page Ref: 10.4

16) Using the VSEPR model, the electron-domain geometry of the central atom in SF_4 is_____.

1. A) linear
2. B) trigonal planar
3. C) tetrahedral
4. D) trigonal bipyramidal
5. E) octahedral

Answer: D

Diff: 3 Page Ref: 10.4

17) What is the $\text{O} \square \text{B} \square \text{O}$ bond angle in BO_3^{3-} ?

- 109. A) less than 109.5°
- 110. B) 109.5°
- 111. C) 120°
- 112. D) greater than 120°

Answer: C

Diff: 3 Page Ref: 10.4

18) What are the $\text{F} \square \text{Po} \square \text{F}$ bond angles in PoF_6^- ?

- 1. A) 60°
- 2. B) 90°
- 3. C) 109.5°
- 4. D) 120°

Answer: B

Diff: 3 Page Ref: 10.4

19) The VSEPR model predicts the $\text{H} \square \text{O} \square \text{H}$ bond angle in H_3O^+ to be

- 1. A) 60° .
- 2. B) 90° .
- 3. C) less than 5° but greater than 90° .
- 4. D) 109.5° .

Answer: C

Diff: 3 Page Ref: 10.4

20) The orbital hybridization on the carbon atoms in C_2H_2 is

1. A)
2. B) sp^2 .
3. C) sp^3 .
4. D) sp^3d^2 .

Answer: A

Diff: 2 Page Ref: 10.7

21) The hybrid orbital set used by the central atom in NO_3^- is _____.

1. A) sp
2. B) sp^2
3. C) sp^3
4. D) sp^3d
5. E) sp^3d^2

Answer: B

Diff: 2 Page Ref: 10.7

22) The hybrid orbital set used by the central atom in PCl_3 is _____.

1. A) sp
2. B) sp^2
3. C) sp^3
4. D) sp^3d
5. E) sp^3d^2

Answer: C

Diff: 2 Page Ref: 10.7

23) The hybrid orbital set used by the central atom in KrF_2 is _____.

1. A) sp
2. B) sp²
3. C) sp³
4. D) sp³d
5. E) sp³d²

Answer: D

Diff: 2 Page Ref: 10.7

Matching Questions

Match the following.

1. A) trigonal planar
2. B) polar, but contains no polar bonds
3. C) tetrahedral
4. D) trigonal bipyramidal
5. E) sp hybridized central atom
6. F) see-saw molecular geometry
7. G) octahedral electron geometry
8. H) octahedral
9. I) polar
10. J) sp² hybridized central atom
11. K) linear
12. L) nonpolar, but contains a polar covalent bond

1) SF₄

Diff: 3 Page Ref: 10.4

2) XeCl₄

Diff: 3 Page Ref: 10.4

3) CH₂F₂

Diff: 2 Page Ref: 10.5

4) BCl₃

Diff: 2 Page Ref: 10.5

5) sp

Diff: 1 Page Ref: 10.7

6) sp²

Diff: 1 Page Ref: 10.7

7)sp³

Diff: 1 Page Ref: 10.7

8)sp³d

Diff: 1 Page Ref: 10.7

9) sp^3d^2

Diff: 1 Page Ref: 10.7

10) BeF_2

Diff: 2 Page Ref: 10.7

Answers: 1) F 2) G 3) I 4) L 5) K 6) A 7) C 8) D 9) H 10) E

Short Answer Questions

1) Is it possible for a molecule to be nonpolar even though it contains polar bonds? Explain your answer and give an example.

Answer: Yes. The polarity of a molecule depends on the molecular geometry and whether or not all of the dipoles (polar bonds) cancel one another. If the molecular geometry causes all of the dipoles to cancel, the molecule will be nonpolar. An example is CF_4 where there are four polar bonds, but the dipoles sum to 0 making the molecule nonpolar.

Diff: 1 Page Ref: 10.5

2) Explain why oil and water do not mix.

Answer: Water molecules are polar and oil molecules are not polar.

Diff: 1 Page Ref: 10.5

3) Determine the molecular geometry about each interior atom in the following structure. Sketch the three-dimensional structure and label the interior atoms with the corresponding molecular geometry.



Answer: The sketch should show all of the appropriate multiple bonds, with a double bond between carbons 1 and 2 and a triple bond between carbons 3 and 4. The first two carbons are trigonal planar, the second carbons are linear and the last carbon is tetrahedral.

Diff: 5 Page Ref: 10.7

4) Give the electron geometry, molecular geometry, and hybridization for both carbons in CH₃COOH.

Answer: eg = tetrahedral; mg = tetrahedral; sp³ and eg = trigonal planar; mg = trigonal planar; sp²

Diff: 5 Page Ref: 10.7

5) Determine the hybridization about each interior atom in the following structure. Sketch the 3 dimensional structure and label the interior atoms with their corresponding hybridization.



Answer: The sketch should show all of the appropriate multiple bonds, with a double bond between carbons 1 and 2 and a triple bond between carbons 3 and 4. The first 2 C's are sp² hybridized, the next 2 C's are sp hybridized and the last C is sp³ hybridized.

Diff: 5 Page Ref: 10.7

6) According to molecular orbital theory, what is an antibonding orbital?

Answer: An antibonding orbital is formed when 2 orbitals destructively interfere with one another. An antibonding orbital is usually higher in energy than the two separated atoms and has a node in the internuclear region.

Diff: 2 Page Ref: 10.8

7) Use molecular orbital theory to determine whether He_2^{2+} or He_2^+ is more stable. Draw the molecular orbital diagram for each and explain your answer.

Answer: The MO diagram should show He_2^{2+} with 2 electrons in the bonding orbital and the MO diagram of He_2^+ should show 2 electrons in the bonding MO and 1 electron in the antibonding MO. The He_2^{2+} ion is more stable since it has a higher bond order (bond order = 1) than He_2^+ (bond order = 1/2).

Diff: 3 Page Ref: 10.8

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