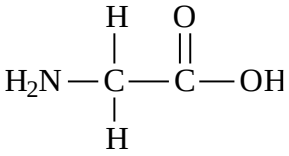
64 Practice Problems – Chapter 14 – Chem 1C

1. Which of the following molecules contains a nitrogen atom that is sp^2 hybridized?
   A) NH_3
   B) NO_3^-
   C) N_2
   D) HCN
   E) C_2N_2

2. Consider the structure of glycine, the simplest amino acid:



   What is the total number of π bonds in the molecule?

   A) 0
   B) 1/2
   C) 1
   D) 2
   E) More information is needed.

3. What is the hybridization of I in the molecule ICl_3?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

4. What is the hybridization of S in the molecule H_2S?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

5. What is the hybridization of C in the ion CN^-?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

6. Atoms that are sp^3 hybridized form ____ pi bond(s).
   A) 0
   B) 1
   C) 2
   D) 3
   E) 4

7. What is the hybridization of the central atom in SF_6?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

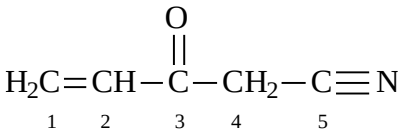
8. What is the hybridization of the central atom in PCl_4^+?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

9. What is the hybridization of the central atom in IF_5?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

10. What is the hybridization of the central atom in SF_4?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

11. What is the hybridization of O in OF_2?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

12. Consider the following molecule. (Lone pairs are not drawn in.)



   Specify the hybridization of each carbon atom (in numeric order: C-1 C-2 C-3 C-4 C-5).

   A) sp^2 sp^2 sp^2 sp^3 sp
   B) sp^2 sp^2 sp^2 sp^3 sp^3
   C) sp^2 sp^2 sp^3 sp^3 sp
   D) sp^2 ssp^2 sp^3 sp^3 sp^3
   E) sp sp sp sp^2 sp

13. What is the hybridization of the phosphorus atom in PF_4^+?
   A) dsp^2
   B) sp^2
   C) d^2sp^3
   D) sp^2d
   E) sp^3

14. What is the hybridization of the central I atom in the molecule ICl_5?
   A) sp
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

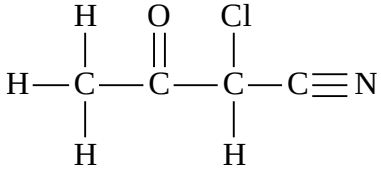
15. Which of the following has a central atom that is dsp^3 hybridized?
    A) SF_4^-
    B) PF_5
    C) CF_4
    D) SCl_6
    E) SO_2

16. What is the hybridization of the S atom in the molecule SO_3?
    A) sp
    B) sp^2
    C) sp^3
    D) dsp^3
    E) d^2sp^3

17. What is the hybridization of the I atom in the ion IF_4^-?
    A) sp
    B) sp^2
    C) sp^3
    D) dsp^3
    E) d^2sp^3

Use the following to answer questions 18-21:

Consider the following molecule. (Lone pairs are not drawn in.)



18. What is the hybridization of the carbon atom that is double-bonded to oxygen?
    A) sp
    B) sp^2
    C) sp^3
    D) dsp^3
    E) d^2sp^3

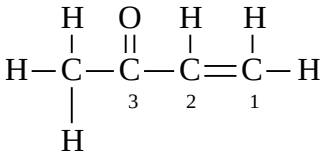
19. What is the hybridization of the carbon atom that is bonded to chlorine?
    A) sp
    B) sp^2
    C) sp^3
    D) dsp^3
    E) d^2sp^3

20. What is the hybridization of the nitrogen atom?
    A) sp
    B) sp^2
    C) sp^3
    D) dsp^3
    E) d^2sp^3

21. What is the hybridization of the oxygen atom?
    A) sp
    B) sp^2
    C) sp^3
    D) dsp^3
    E) d^2sp^3

22. Which of the following has two π bonds?
    A) C_2H_6
    B) C_2H_4
    C) C_2H_2
    D) at least two of these
    E) none of these

23. Consider the following Lewis structure. (Lone pairs are not drawn in.)

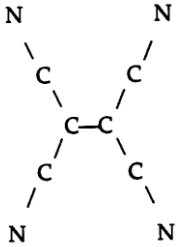


Which statement about the molecule is *false*?

    A) There are 10 sigma and 2 pi bonds.
    B) C-2 is sp^2 hybridized with bond angles of 120.
    C) Oxygen is sp^3 hybridized.
    D) This molecule contains 28 valence electrons.
    E) There are some H–C–H bond angles of about 109° in the molecule.

Use the following to answer questions 24-26:

Tetracyanoethylene has the skeleton shown here:



From its Lewis structure, determine the following.

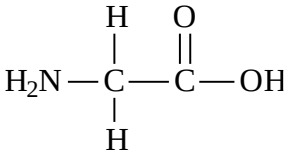
24. How many sigma bonds and how many pi bonds are in the molecule?
    A) 5 sigma and 9 pi
    B) 6 sigma and 8 pi
    C) 9 sigma and 7 pi
    D) 9 sigma and 9 pi
    E) 5 sigma and 8 pi

25. How many of the atoms are sp^2 hybridized?
    A) 2
    B) 4
    C) 6
    D) 8
    E) 10

26. How many of the atoms are sp hybridized?
    A) 2
    B) 4
    C) 6
    D) 8
    E) 10

27. Which statement about N_2 is *false*?
    A) It is a gas at room temperature.
    B) The oxidation state is +3 on one N and –3 on the other.
    C) It has one sigma bond and two pi bonds between the two atoms.
    D) It can combine with H_2 to form NH_3.
    E) It has two pairs of nonbonding electrons.

28. Consider the structure of glycine, the simplest amino acid:



What is the total number of bonds in the molecule?

A) 6
B) 7
C) 8
D) 10
E) 11

29. Which of the following has the shortest N-O bond?
A) NO_3^-
B) NO^+
C) N_2
D) NO_2^-
E) none of these

30. Specify the hybridization of the nitrogen atom in each of the following, in order.
NO_3^- N_2 NO_2^-

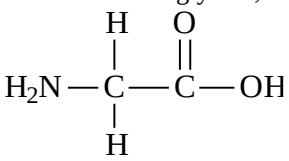
A) sp^3, sp, sp
B) sp^2, sp, sp^2
C) sp^2, sp, sp^3
D) sp^3, sp^2, sp^3
E) none of these

31. In which of the compounds below is there more than one kind of hybridization (sp, sp^2, sp^3) for carbon?
I. $CH_3CH_2CH_2CH_3$
II. $CH_3CH = CHCH_3$
III. $CH_2 = CH – CH = CH_2$
IV. $H – C{\equiv}C – H$

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

32. The C—C—H bond angles in ethylene, C_2H_4, are 120°. What is the hybridization of the carbon orbitals?
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

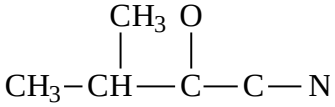
33. Consider the structure of glycine, the simplest amino acid:



Indicate the hybridizations at each N and C atom in the molecule (in sequence from left to right).

A) sp^3 sp^3 sp^2
B) sp^3 sp^3 sp^3
C) sp^2 sp^2 sp^2
D) sp^2 sp^3 sp^2
E) none of these

34. Complete the Lewis structure for the following molecule.

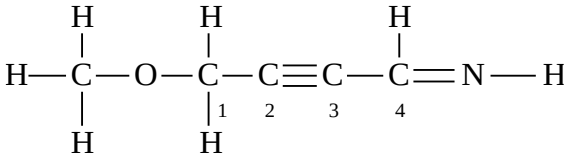


This molecule has _____ sigma bonds and _____ pi bonds.

A) 4, 5
B) 6, 3
C) 11, 5
D) 13, 2
E) 13, 3

35. Describing the bonding in C_2H_4 requires what carbon hybridization?
A) sp^3
B) sp^2
C) sp
D) d^2sp^3
E) dsp^2

36. Consider the following Lewis structure. (Lone pairs are not drawn in.)



What are the hybridizations of the oxygen atom and of carbon atoms 1, 2, and 4, respectively (order: O C-1 C-2 C-4)?

A) sp^3 sp^3 sp sp^2
B) sp sp^3 sp sp
C) sp sp^2 sp sp^2
D) sp^2 sp^3 sp^2 sp^3
E) sp sp^3 sp^2 sp

37. What is the hybridization of each N atom in the molecule N_2H_4?
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

38. Which statement about the thiocyanate ion, SCN^-, is true?
A) Its Lewis structure contains an unpaired electron.
B) Its shape is bent like that of H_2O.
C) Only one correct resonance structure can be drawn.
D) There are more than two σ bonds in the ion.
E) none of these

39. Which of the following statements is correct?
A) A triple bond is composed of two σ bonds and one π bond.
B) σ bonds result from the head-to-head overlap of atomic orbitals.
C) Free rotation may occur about a double bond.
D) π bonds have electron density on the internuclear axis.
E) More than one of these statements are correct.

40. As the bond order of a bond increases, its bond energy _____ and its bond length _____.
A) increases, increases
B) decreases, decreases
C) increases, decreases
D) decreases, increases

41. If four orbitals on one atom overlap four orbitals on a second atom, how many molecular orbitals will form?
A) 1
B) 4
C) 8
D) 16
E) none of these

42. For which of the following diatomic molecules would the bond order become greater if an electron were removed, that is, if the molecule were converted to the positive ion in its ground state?
A) B_2
B) C_2
C) P_2
D) F_2
E) Na_2

43. The configuration $(\sigma_{2s})^2(\sigma_{2s}*)^2(\pi_{2py})^1(\pi_{2px})^1$ is the molecular orbital description for the ground state of which of the following species?
A) Li_2^+
B) Be_2
C) B_2
D) B_2^{2-}
E) C_2

44. Which of the following species has the largest dissociation energy?
A) O_2
B) O_2^-
C) O_2^{2-}
D) O_2^+
E) O_2^{2+}

45. Which of the following is paramagnetic?
A) B_2
B) C_2
C) H_2
D) N_2
E) F_2

46. Order the following from shortest to longest bond: C_2, B_2, H_2, N_2
A) H_2, N_2, C_2, B_2
B) N_2, C_2, B_2, H_2
C) C_2, N_2, H_2, B_2
D) C_2, B_2, H_2, N_2
E) none of these

47. Which charge(s) of O_2 would give a bond order of 3?
A) +1
B) -2
C) +2
D) -1
E) +3

48. Which of the following statements is *false*?
A) C_2 is paramagnetic.
B) C_2 is diamagnetic.
C) The carbon-carbon bond in C_2^{2-} is stronger than the one in CH_3CH_3.
D) The carbon-carbon bond in C_2^{2-} is shorter than the one in CH_3CH_3.
E) Two of these statements are false.

49. Which of the following statements is true?
A) Electrons are never found in an antibonding MO.
B) All antibonding MOs are higher in energy than the atomic orbitals of which they are composed.
C) Antibonding MOs have electron density mainly outside the space between the two nuclei.
D) None of these statements is true.
E) Two of these statements are true.

50. Which of the following is paramagnetic?
A) O_2^-
B) O_2^+
C) O_2
D) N_2
E) At least two of these are paramagnetic.

51. Which of the following is diamagnetic?
A) O_2^-
B) F_2^+
C) B_2
D) N_2
E) NO

52. For how many of B_2, C_2, P_2, and F_2 does bond order decrease if one electron is removed from the neutral molecule?
A) 0
B) 1
C) 2
D) 3
E) 4

53. Which of the following statements is *false*?
A) Atoms or molecules with an even number of electrons are diamagnetic.
B) Atoms or molecules with an odd number of electrons are paramagnetic.
C) Paramagnetism cannot be deduced from the Lewis structure of a molecule alone.
D) Paramagnetic molecules are attracted toward a magnetic field.
E) N_2 molecules are diamagnetic.

54. For how many of the following does the bond order decrease if you add one electron to the neutral molecule?
B_2, Si_2, P_2, F_2

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

55. Which of the following species is paramagnetic?
A) C_2
B) B_2
C) N_2
D) H_2
E) none of these

56. The fact that O_2 is paramagnetic can be explained by
A) the Lewis structure of O_2.
B) resonance.
C) a violation of the octet rule.
D) the molecular-orbital diagram for O_2.
E) hybridization of atomic orbitals in O_2.

57. The molecular-orbital electron configuration below
$(\sigma_{1s})^2 \quad (\sigma_{1s}^*)^2 \quad (\sigma_{2s})^2 \quad (\sigma_{2s}^*)^2 \quad (\pi_{2p})^4 \quad (\sigma_{2p})^2$

applies to which of the following molecules?

A) F_2
B) O_2
C) BC
D) NO
E) CO

58. Which of the following electron distributions among the molecular orbitals best describes the NO molecule?

	σ_{2s}	σ_{2s}^*	$\pi_{2py} = \pi_{2px}$	σ_{2pz}	$\pi_{2py}^* = \pi_{2px}^*$	σ_{2pz}^*
I.	2	2	4	2	4	2
II.	2	2	4	2	4	1
III.	2	2	4	1	3	0
IV.	2	2	4	2	2	0
V.	2	2	4	2	1	0

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

59. Consider the molecular-orbital energy-level diagrams for O_2 and NO. Which of the following is true?

I. Both molecules are paramagnetic.

II. The bond strength of O_2 is greater than the bond strength of NO.

III. NO is an example of a homonuclear diatomic molecule.

IV. The ionization energy of NO is smaller than the ionization energy of NO^+.

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

60. In the molecular-orbital description of CO,
A) the highest energy electrons occupy antibonding orbitals.
B) six molecular orbitals contain electrons.
C) there are two unpaired electrons.
D) the bond order is 3.
E) All of these are false.

61. Consider the molecular-orbital description of the NO^- anion. Which of the following statements is *false*?
A) NO^- is paramagnetic.
B) NO^- is isoelectronic with CO.
C) The bond energy in NO^+ is greater than the bond energy in NO^-.
D) The bond order in NO^- is 2.
E) All of these statements are false.

62. The bond order in the NO^+ ion is
A) 1
B) 1.5
C) 2.5
D) 3
E) 2

63. How many electrons are involved in pi bonding in benzene, C_6H_6?
A) 12
B) 30
C) 3
D) 6
E) 18

64. Which of the following statements about the CO_3^{2-} ion is *false*?
A) The orbitals on the carbon atom are sp^2 hybridized.
B) The ion is expected to be diamagnetic.
C) One C–O bond is shorter than the others.
D) The ion has a total of 24 electrons.
E) It has a planar molecular geometry.

1.	B	11.	C	21.	B	31.	B	41.	C	51.	D	61.	B
2.	C	12.	A	22.	C	32.	B	42.	D	52.	D	62.	D
3.	D	13.	E	23.	C	33.	A	43.	C	53.	A	63.	D
4.	C	14.	E	24.	D	34.	E	44.	E	54.	C	64.	C
5.	A	15.	B	25.	A	35.	B	45.	A	55.	B		
6.	A	16.	B	26.	D	36.	A	46.	A	56.	D		
7.	E	17.	E	27.	B	37.	C	47.	C	57.	E		
8.	C	18.	B	28.	D	38.	E	48.	A	58.	E		
9.	E	19.	C	29.	B	39.	B	49.	E	59.	C		
10.	D	20.	A	30.	B	40.	C	50.	E	60.	D		