

Organic Chemistry, 7e (Bruice)

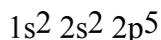
Chapter 1 Remembering General Chemistry: Electronic Structure and Bonding

1) Atoms with the same number of protons but different numbers of neutrons are called _____.

Answer: isotopes

Section: 1-1

2) Which of the following elements does this electronic configuration represent?



A) F

B) C

C) N

D) Al

E) O

Answer: A

Section: 1-2

3) How many unpaired electrons are present in the isolated carbon atom (atomic number = 6)?

A) none

B) one

C) two

D) three

E) four

Answer: C

Section: 1-2

4) Which of the following is the electronic configuration of the element Fe?

A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

B) $1s^2 2s^2 2p^6 3s^2 3p^8 3d^6$

C) $1s^2 2s^2 2p^8 3s^2 3p^6 4s^2 3d^6$

D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^6$

E) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6$

Answer: A

Section: 1-2

5) The atomic number of boron is 5. The correct electronic configuration of boron is _____.

A) $1s^2 2s^3$

B) $1s^2 2p^3$

C) $1s^2 2s^2 2p^1$

D) $2s^2 2p^3$

E) $1s^2 2s^2 3s^1$

Answer: C

Section: 1-2

6) Which of the following statements correctly describes the third electron shell that surrounds the nucleus of an atom?

- A) The third shell contains only *s* and *p* atomic orbitals.
- B) The maximum number of electrons that can occupy the third shell is 18.
- C) The total number of atomic orbitals present in the third shell is 16.
- D) The third shell can contain *f* orbitals.
- E) All third shell elements must have *d* electrons.

Answer: B

Section: 1-2

7) Ar, K⁺, Cl⁻ are isoelectronic elements (elements with the same number of electrons). What orbital does the last electron occupy?

Answer: 3p orbital

Section: 1-2

8) Give the electronic configuration for N⁻³.

- A) 1s²2s²
- B) 1s²2s²2p³
- C) 1s²2s²2p⁴
- D) 1s²2s²2p⁶
- E) 1s²2s²2p⁶3s¹

Answer: D

Section: 1-2

9) Give the electronic configuration for Ca⁺².

Answer: 1s²2s²2p⁶3s²3p⁶

Section: 1-2

10) Identify the least electronegative atom.

- A) P
- B) Na
- C) I
- D) B
- E) O

Answer: B

Section: 1-3

11) Give the number of nonbonding pairs of electrons in H₂NOH.

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

Answer: D

Section: 1-3

12) The compound methylamine, CH_3NH_2 , contains a C-N bond. In this bond, which of the following best describes the charge on the nitrogen atom?

- A) +1
- B) slightly positive
- C) uncharged
- D) slightly negative
- E) -1

Answer: D

Section: 1-3

13) Which of the compounds below have bonds that are predominantly ionic?

- A) KCl
- B) CF_4
- C) NH_3
- D) both A and B
- E) both B and C

Answer: A

Section: 1-3

14) What type of bonding is most important in $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$?

- A) ionic
- B) hydrogen
- C) covalent
- D) polar

Answer: C

Section: 1-3

15) Which of the following contain(s) polar covalent bonds?

- A) NH_3
- B) Na_2O
- C) H_2
- D) KF
- E) both A and C

Answer: A

Section: 1-3

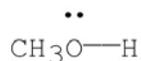
16) Which of the following covalent bonds has the largest dipole moment?

- A) C-C
- B) C-H
- C) C-O
- D) H-N
- E) H-F

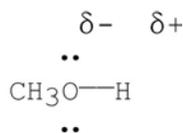
Answer: E

Section: 1-3

17) Using the symbol δ^+ and δ^- , show the direction of the polarity in the indicated bond.



Answer:



Section: 1-3

18) Covalent bonds may be polar or nonpolar. What property of the atoms forming a given bond determines this?

Answer: electronegativity

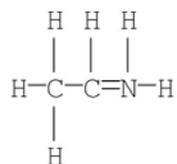
Section: 1-3

19) Provide the mathematical equation for the dipole moment of a bond, and identify the variables.

Answer: $\mu = e \times d$, where μ is the bond dipole moment, e is the amount of charge which is separated, and d is the distance over which the charge is separated.

Section: 1-3

20) The formal charge on nitrogen in the compound below is _____.



A) +2

B) +1

C) 0

D) -1

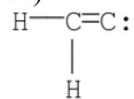
E) -2

Answer: B

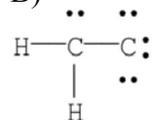
Section: 1-4

21) Which of the following is the most likely electronic structure for C₂H₂?

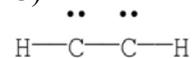
A)



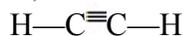
B)



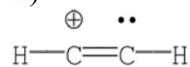
C)



D)



E)



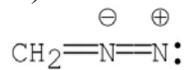
Answer: D

Section: 1-4

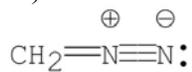
22) Which of the following structures, including formal charges, is correct for diazomethane, CH₂N₂?

A) :CH₂—N=N :

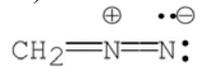
B)



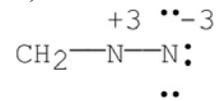
C)



D)



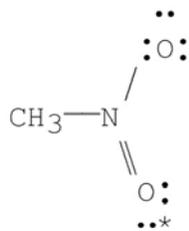
E)



Answer: D

Section: 1-4

23) What are the formal charges on nitrogen and the starred oxygen atom in the following molecule?



- A) N = -1, O = 0
 B) N = +1, O = -1
 C) N = +1, O = +1
 D) N = -1, O = -1
 E) N = +1, O = 0

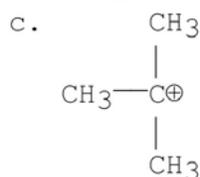
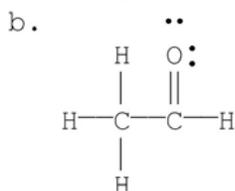
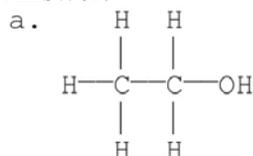
Answer: E

Section: 1-4

24) Draw the Kekulé structure for each of the following:

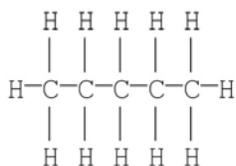
- a. $\text{CH}_3\text{CH}_2\text{OH}$ b. CH_3CHO c. $(\text{CH}_3)_3\text{C}^+$

Answer:



Section: 1-4

25) The Kekulé structure of pentane is shown below. Draw the condensed structural formula which corresponds to this Lewis structure.



Answer: $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$

Section: 1-4

31) How many distinct and degenerate p orbitals exist in the second electron shell, where $n = 2$?

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

Answer: D

Section: 1-5

32) Draw the shape of a 2p orbital.

Answer:



Section: 1-5

33) Consider the interaction of two hydrogen 1s atomic orbitals of the same phase. Which of the statements below is an **incorrect** description of this interaction?

- A) A sigma bonding molecular orbital is formed.
- B) The molecular orbital formed is lower in energy than a hydrogen 1s atomic orbital.
- C) The molecular orbital formed has a node between the atoms.
- D) The molecular orbital formed is cylindrically symmetric.
- E) A maximum of two electrons may occupy the molecular orbital formed.

Answer: C

Section: 1-6

34) Both sigma (σ) and pi (π) bonds can be formed by overlapping p orbitals. Describe the difference.

Answer: Sigma bonds are formed from the overlap of atomic orbitals along a circular axis of symmetrical nature, i.e., head-on overlap. All single bonds are sigma bonds.

Pi bonds are formed from the overlap of atomic orbitals along a non-symmetrical (parallel) axis, i.e., side-to-side overlap. Double and triple bonds contain both sigma and pi bonds.

Section: 1-6

35) What kind of molecular orbital (σ , σ^* , π , or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: σ^*

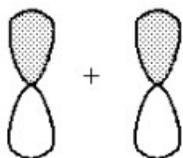
Section: 1-6

36) What kind of molecular orbital (σ , σ^* , π , or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: σ
Section: 1-6

37) What kind of molecular orbital (σ , σ^* , π , or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



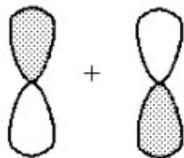
Answer: π
Section: 1-6

38) What kind of molecular orbital (σ , σ^* , π , or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: σ^*
Section: 1-6

39) What kind of molecular orbital (σ , σ^* , π , or π^*) results when the two atomic orbitals shown below interact in the manner indicated?



Answer: π^*
Section: 1-6

40) Choose the correct hybridization for the atom indicated in the molecule below.



↑

- A) sp
- B) sp²
- C) sp³
- D) none of the above

Answer: C

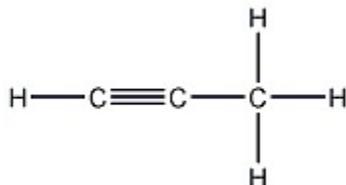
Section: 1-7

41) What orbitals are used to form the covalent bonds in butane (CH₃CH₂CH₂CH₃)?

Answer: The carbon-carbon σ bonds are formed by the overlap of two carbon sp³ hybrid atomic orbitals. The carbon-hydrogen σ bonds are formed by the overlap of a carbon sp³ hybrid atomic orbital and a hydrogen s orbital.

Section: 1-7

42) How many carbon-carbon sigma bonds are in the molecule shown?



- A) 1
- B) 2
- C) 3
- D) 4

Answer: B

Section: 1-7

43) A molecule of acetonitrile CH₃CN contains _____ sigma bonds and _____ pi bonds.

- A) 5, 2
- B) 4,3
- C) 4,2
- D) 2,2
- E) 4,0

Answer: A

Section: 1-7

48) Which of the following is an sp^2 hybridized carbon?

- A) $\oplus \text{CH}_3$
B) $\cdot \text{CH}_3$
C) $\ominus \text{:CH}_3$
D) A and B
E) A, B and C

Answer: A

Section: 1-10

49) What is the predicted shape, bond angle, and hybridization for $^+\text{CH}_3$?

- A) trigonal planar, 120° , sp^2
B) trigonal planar, 120° , sp^3
C) trigonal planar, 109.5° , sp^2
D) trigonal pyramidal, 120° , sp^2
E) trigonal pyramidal, 109.5° , sp^2

Answer: A

Section: 1-10

50) What orbitals overlap to create the H-C bond in CH_3^+ ?

- A) sp^3 - sp^3
B) sp^2 - sp^3
C) s-p
D) s- sp^2
E) s- sp^3

Answer: D

Section: 1-10

51) The lone-pair electrons of the methyl anion occupy a(n) _____ orbital.

- A) s
B) p
C) sp
D) sp^2
E) sp^3

Answer: E

Section: 1-10

52) Give the shape of the methyl radical.

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

Answer: E

Section: 1-10

53) The N-H single bond in methyl amine (CH_3NH_2) is a _____ bond formed by the overlap of a(n) _____ orbital on N and a(n) _____ orbital on H.

- A) σ ; sp^2 ; s
- B) σ ; sp^3 ; s
- C) π ; sp^3 ; s
- D) π ; sp^2 ; p
- E) π ; p; p

Answer: B

Section: 1-11

54) Triethylamine [$(\text{CH}_3\text{CH}_2)_3\text{N}$] is a molecule in which the nitrogen atom is _____ hybridized and the C-N-C bond angle is _____.

- A) sp^2 , $>109.5^\circ$
- B) sp^2 , $<109.5^\circ$
- C) sp^3 , $>109.5^\circ$
- D) sp^3 , $<109.5^\circ$
- E) sp, 109.5°

Answer: D

Section: 1-11

55) The N-H bond in the ammonium ion, NH_4^+ , is formed by the overlap of what two orbitals?

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

Answer: E

Section: 1-11

56) Which of the following is closest to the C-O-C bond angle in CH₃-O-CH₃?

- A) 180°
- B) 120°
- C) 109.5°
- D) 90°
- E) 160°

Answer: C

Section: 1-12

57) Each lone pair of electrons on the O atom in methanol (CH₃OH) occupies a(n) _____ orbital.

- A) s
- B) p
- C) sp
- D) sp²
- E) sp³

Answer: E

Section: 1-12

58) Among the hydrogen halides, the strongest bond is found in _____ and the longest bond is found in _____.

- A) HF, HF
- B) HF, HI
- C) HI, HF
- D) HI, HI
- E) HCl, HBr

Answer: B

Section: 1-13

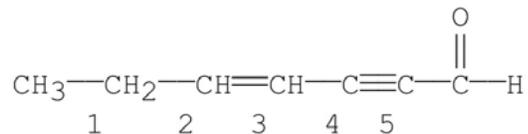
59) The hydrogen—halogen bond becomes _____ and _____ as the size (atomic weight) of the halogen increases.

- A) longer, weaker
- B) longer, stronger
- C) shorter, weaker
- D) shorter, stronger

Answer: A

Section: 1-13

60) Which bond in the following molecule is the shortest?

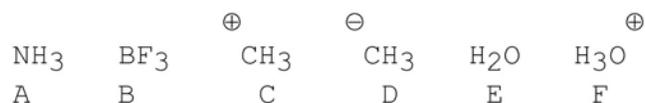


- A) bond 1
- B) bond 2
- C) bond 3
- D) bond 4
- E) bond 5

Answer: E

Section: 1-15

61) Which of the following species have tetrahedral bond angles?



- A) A, D and E
- B) A, D, E and F
- C) A and E
- D) D only
- E) A, B and E

Answer: B

Section: 1-15

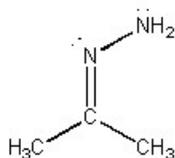
62) The carbon-carbon double bond in ethene is _____ and _____ than the carbon-carbon triple bond in ethyne.

- A) stronger; shorter
- B) stronger; longer
- C) weaker; shorter
- D) weaker; longer
- E) stronger; more polar

Answer: D

Section: 1-15

63) What is the CNN bond angle in the compound shown below?



- A) $\sim 60^\circ$
- B) $\sim 90^\circ$
- C) $\sim 110^\circ$
- D) $\sim 120^\circ$
- E) $\sim 180^\circ$

Answer: D

Section: 1-15

64) Draw the structure of a molecule which contains only carbon and hydrogen atoms (only three of which are carbon) and in which two of the carbons are sp^2 hybridized and the other is sp hybridized.

Answer: $\text{H}_2\text{C}=\text{C}=\text{CH}_2$

Section: 1-15

65) Why is the C—H bond in ethene ($\text{H}_2\text{C}=\text{CH}_2$) shorter and stronger than the C—H bond in ethane (CH_3CH_3)?

Answer: The length and strength of a C—H bond depends on the hybridization of the carbon atom. The more s character in the hybrid orbital used by carbon to form the bond, the shorter and stronger the bond. This is because an s orbital is closer to the nucleus than is a p . Ethene uses carbon sp^2 hybrid orbitals ($1/3 s$ character) to make its carbon-hydrogen bonds while ethane uses carbon sp^3 ($1/4 s$ character).

Section: 1-15

66) How many nonbonding electron pairs, bonding electron pairs, pi bonds, and sigma bonds are present in CO_2 ?

Answer: 4 nonbonding electron pairs, 4 bonding electrons pairs, 2 pi bonds, 2 sigma bonds

Section: 1-15

67) Identify the hybridization of carbon in H_2CO .

- A) sp
- B) sp^2
- C) sp^3
- D) sp^4
- E) s^3p

Answer: B

Section: 1-15

68) Give the H-C-H bond angle in H_2CO .

- A) 60
- B) 90
- C) 109.5
- D) 120
- E) 180

Answer: D

Section: 1-15

69) Identify the hybridization of the oxygen in CH_3OCH_3 .

- A) sp
- B) sp^2
- C) sp^3
- D) sp^4
- E) sp^5

Answer: C

Section: 1-15

70) Give the hybridizations of the carbons, from left to right, in $\text{CH}_3\text{CH}=\text{CHCl}$.

Answer: sp^3 , sp^2 , sp^2

Section: 1-15

71) Give the hybridization, shape, and bond angle for the carbon in CO_2 .

Answer: sp, linear, 180

Section: 1-15

72) Give the hybridization, shape, and bond angle for each carbon in CH_3CN .

Answer: CH_3 - sp^3 , tetrahedral, 109.5; C - sp, linear, 180

Section: 1-15

73) Identify the compound with the weakest bond.

- A) H_2
- B) HF
- C) HCl
- D) HBr
- E) HI

Answer: E

Section: 1-15

74) Identify the hybridization of the nitrogen atom in the molecule $(\text{CH}_3)_3\text{N}$.

Answer: sp^3

Section: 1-15

75) In what type of orbital are the lone pair electrons of methoxide (CH_3O^-) found ?

- A) s
- B) p
- C) sp
- D) sp^2
- E) sp^3

Answer: E

Section: 1-15

76) Which of the following molecules does not exhibit a net dipole moment of zero?

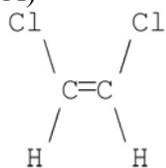
- A) CO_2
- B) CH_4
- C) CCl_4
- D) H_2O
- E) SO_3

Answer: D

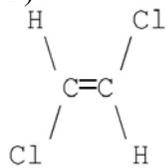
Section: 1-16

77) Which of the following molecules has a net dipole moment of zero?

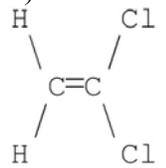
A)



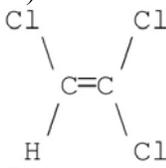
B)



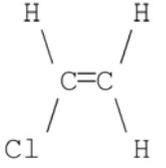
C)



D)



E)



Answer: B

Section: 1-16

78) Which of the following molecules has the smallest dipole moment?

A) Br₂

B) NH₃

C) HCl

D) HBr

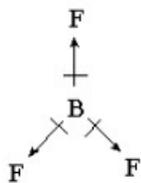
E) HI

Answer: A

Section: 1-16

79) BF_3 has a dipole moment of zero. Propose a structure for BF_3 that is consistent with this information.

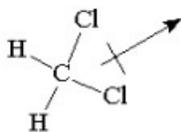
Answer: BF_3 is trigonal planar.



Section: 1-16

80) Draw the Kekulé structure and show the direction of the dipole moment for CH_2Cl_2 .

Answer:



Section: 1-16

81) Identify the compound(s) that have a nonzero dipole moment.

A) CH_3NH_2

B) CO_2

C) CH_3OCH_3

D) $(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2$

E) BCl_3

Answer: A, C

Section: 1-16