Essential Organic Chemistry, 3e **(Bruice)**
Chapter 1 Remembering General Chemistry: Electronic Structure and Bonding

1) What element is represented by the following electronic configuration?
$1s^2\ 2s^2\ 2p^5$
A) F
B) C
C) N
D) Al
E) O
Answer: A
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

2) How many unpaired electrons are present in the electronic configuation of carbon (atomic number = 6)?
A) none
B) one
C) two
D) three
E) four
Answer: C
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

3) 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
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

4) The atomic number of boron is 5. The correct electronic configuration of boron is _____.
A) $1s^2\ 2s3$
B) $1s^2\ 2p3$
C) $1s^2\ 2s2\ 2p1$
D) $2s^2\ 2p3$
E) $1s^2\ 2s2\ 3s1$
Answer: C
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

5) Which of the following statements correctly describes the third 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
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

6) What is the electronic configuration of N^{3-}?
A) $1s^2\ 2s2$
B) $1s^2\ 2s^2\ 2p^3$
C) $1s^2\ 2s^2\ 2p^4$
D) $1s^2\ 2s^2\ 2p^6$
E) $1s^2\ 2s^2\ 2p^6\ 3s^1$
Answer: D
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

7) Which of the following atoms is the least electronegative?
A) P
B) Na
C) I
D) B
E) O
Answer: B
Diff: 2
Section: 1-3
Objective: G2, G3
LO: 1.4

8) Which of the following compounds 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
Diff: 2
Section: 1-3
Objective: G2, G3
LO: 1.3

9) What type of bonding is found in $CH_3CH_2CH_2CH_2CH_2CH_3$?
A) ionic
B) hydrogen
C) covalent
D) polar
Answer: C
Diff: 2
Section: 1-3
Objective: G2, G3
LO: 1.3

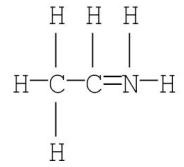
10) Which of the following contains polar covalent bonds?
A) NH_3
B) Na_2O
C) H_2
D) KF
E) both A and C
Answer: A
Diff: 2
Section: 1-3
Objective: G2, G3
LO: 1.3

11) 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
Diff: 2
Section: 1-3
Objective: G2, G3
LO: 1.3

12) How many nonbonding pairs of electrons are in H_2NOH?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: D
Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.4

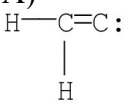
13) The compound CH_3NH_2, contains a C-N bond. Which of the following best describes the charge on the nitrogen atom in this compound?
A) +1
B) slightly positive
C) uncharged
D) slightly negative
E) -1
Answer: D
Diff: 2
Section: 1-4
Objective: G2, G3
LO: 1.4

14) The formal charge on nitrogen in the following compound is _____.

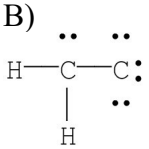


A) +2
B) +1
C) 0
D) -1
E) -2
Answer: B
Diff: 2
Section: 1-4
Objective: G2, G3
LO: 1.5

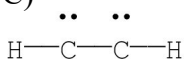
15) Which of the following is the most likely Lewis structure for C_2H_2?
A)



B)

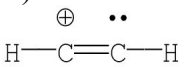


C)



D)

E)

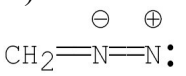


Answer: D
Diff: 2
Section: 1-4
Objective: G2, G3
LO: 1.5

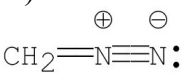
16) Which of the following Lewis structures is correct for CH_2N_2?

A) : CH_2—N═N :

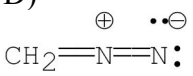
B)



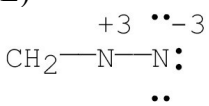
C)



D)

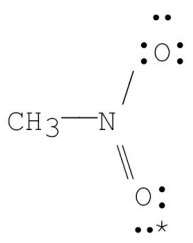


E)



Answer: D
Diff: 2
Section: 1-4
Objective: G2, G3
LO: 1.5

17) What are the formal charges on nitrogen and on the starred oxygen in the following species?



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
Diff: 2
Section: 1-4
Objective: G2, G3
LO: 1.5

18) What is the formal charge on the nitrogen in the ammonium ion?
A) -2
B) -1
C) 0
D) +1
E) +2
Answer: D
Diff: 2
Section: 1-4
Objective: G2, G3
LO: 1.5

19) How many degenerate *p* orbitals are in the second shell?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: D
Diff: 2
Section: 1-5
Objective: G2, G3
LO: 1.7

20) What is the hybridization of the indicated atom ?

$CH_3CH_2CH_2CH_3$

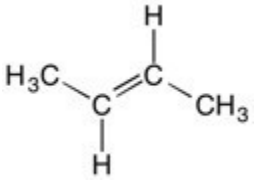
↑

A) *sp*
B) sp^2
C) sp^3
D) none of the above
Answer: C
Diff: 2
Section: 1-7
Objective: G2, G3
LO: 1.9

21) How many sp^2 carbons are present in $H_2C=C=CH_2$?
A) 0
B) 1
C) 1.5
D) 2
E) 3
Answer: D
Diff: 2
Section: 1-8
Objective: G2, G3
LO: 1.10a

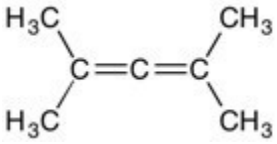
22) What orbitals overlap to form the C-H bond in ethene ($H_2C=CH_2$)?
A) *s*-*sp*
B) *s*-sp^2
C) *s*-sp^3
D) *s*-*p*
E) *p*-*p*
Answer: B
Diff: 2
Section: 1-8
Objective: G2, G3
LO: 1.10a

23) Are all the carbons in this structure in the same plane?



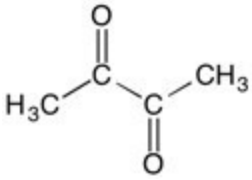
A) Yes
B) No
Answer: A
Diff: 2
Section: 1-8
Objective: G2, G3
LO: 1.10a

24) Are all the carbons in this structure in the same plane?



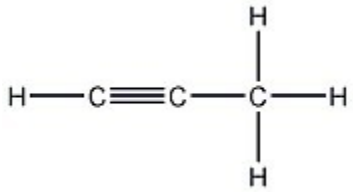
A) Yes
B) No
Answer: B
Diff: 2
Section: 1-8
Objective: G2, G3
LO: 1.10a

25) How many *sp*2-hybridized atoms are in the following compound?



A) Two
B) Three
C) Four
D) Five
E) Six
Answer: C
Diff: 2
Section: 1-8
Objective: G2, G3
LO: 1.10a

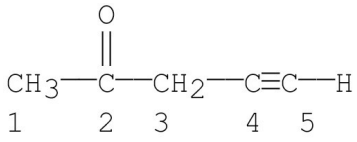
26) How many carbon-carbon sigma bonds are in the following compound?



A) 1
B) 2
C) 3
D) 4
Answer: B
Diff: 3
Section: 1-9
Objective: G2, G3
LO: 1.11

27) CH_3CN contains _____ sigma bonds and _____ pi bonds.
A) 5; 2
B) 4; 3
C) 4; 2
D) 2; 2
E) 4; 0
Answer: A
Diff: 2
Section: 1-9
Objective: G2, G3
LO: 1.11

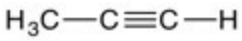
28) Which carbons in the following compound are *sp* hybridized?



A) carbon 1
B) carbon 2
C) carbons 1, 3
D) carbons 4
E) carbons 4, 5
Answer: E
Diff: 2
Section: 1-9
Objective: G2, G3
LO: 1.11

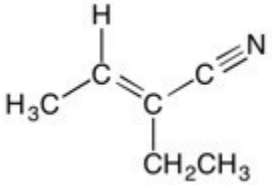
29) How many carbon-carbon sigma bonds are in the following compound?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: C
Diff: 3
Section: 1-9
Objective: G2, G3
LO: 1.11

30) How many *sp* carbons are in the following compound?



A) Zero
B) One
C) Two
D) Three
Answer: C
Diff: 2
Section: 1-9
Objective: G2, G3
LO: 1.11

31) How many *sp*-hybridized atoms are in the following compound?



A) One
B) Two
C) Three
D) Four
Answer: B
Diff: 2
Section: 1-9
Objective: G2, G3
LO: 1.11

32) Which of the following has an sp^2 carbon?
A)

B) 
C)

D) A and B
E) A, B and C
Answer: D
Diff: 2
Section: 1-10
Objective: G2, G3
LO: 1.12

33) What is the bond angle and hybridization of the carbon in $^{+}CH_3$?
A) 120°, sp^2
B) 120°, sp^3
C) 109.5°, sp^2
D) 120°, sp^2
E) 109.5°, sp^2
Answer: A
Diff: 2
Section: 1-10
Objective: G2, G3
LO: 1.12

34) What orbitals overlap to form 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
Diff: 2
Section: 1-10
Objective: G2, G3
LO: 1.12

35) 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
Diff: 2
Section: 1-10
Objective: G2, G3
LO: 1.12

36) The N-H bond in CH_3NH_2 is a _____ bond formed by the overlap of a(n) _____ orbital of N with the _____ orbital of 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
Diff: 2
Section: 1-11
Objective: G2, G3
LO: 1.13

37) The nitrogen atom in $(CH_3CH_2)_3N$ is _____ hybridized and the C-N-C bond angle is _____.
A) sp^2; >109.5°
B) sp^2; <109.5°
C) sp^3; >109.5°
D) sp^3; <109.5°
E) *sp*; 109.5°
Answer: D
Diff: 2
Section: 1-11
Objective: G2, G3
LO: 1.13

38) 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
Diff: 2
Section: 1-11
Objective: G2, G3
LO: 1.13

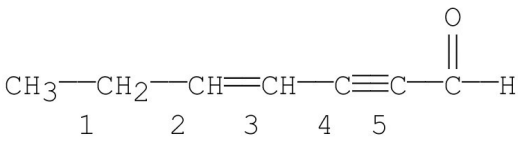
39) Which of the following angles is closest to the C-O-C bond angle in CH_3-O-CH_3?
A) 180°
B) 120°
C) 109.5°
D) 90°
E) 160°
Answer: C
Diff: 2
Section: 1-12
Objective: G2, G3
LO: 1.14

40) Each lone pair on the O in CH_3OH occupies a(n) _____ orbital.
A) *s*
B) *p*
C) *sp*
D) sp^2
E) sp^3
Answer: E
Diff: 2
Section: 1-12
Objective: G2, G3
LO: 1.14

41) Of 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
Diff: 2
Section: 1-13
Objective: G2, G3
LO: 1.15

42) The hydrogen—halogen bond becomes _____ and _____ as the size of the halogen increases.
A) longer; weaker
B) longer; stronger
C) shorter; weaker
D) shorter; stronger
Answer: A
Diff: 3
Section: 1-13
Objective: G2, G3
LO: 1.15

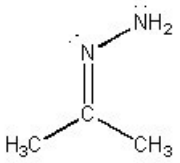
43) Which bond in the following compound is the shortest?



A) bond 1
B) bond 2
C) bond 3
D) bond 4
E) bond 5
Answer: E
Diff: 2
Section: 1-14
Objective: G2, G3
LO: 1.16

44) 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
Diff: 2
Section: 1-14
Objective: G2, G3
LO: 1.16

45) What is the C—N—N bond angle in the following compound?



A) ~60°
B) ~90°
C) ~110°
D) ~120°
E) ~180°
Answer: D
Diff: 2
Section: 1-14
Objective: G2, G3
LO: 1.17

46) What is the hybridization of the carbon in H_2CO?
A) *sp*
B) sp^2
C) sp^3
D) sp^4
E) s^3p
Answer: B
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.17

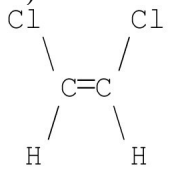
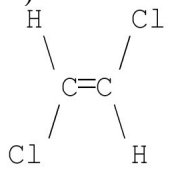
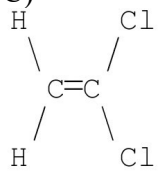
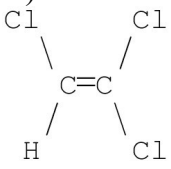
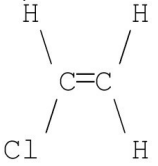
47) What is the H-C-H bond angle in H_2CO?
A) 60°
B) 90°
C) 109.5°
D) 120°
E) 180°
Answer: D
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.17

48) What is 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
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.17

49) Which of the following compounds has the weakest bond?
A) H_2
B) HF
C) HCl
D) HBr
E) HI
Answer: E
Diff: 1
Section: 1-14
Objective: G2, G3
LO: 1.16

50) In which orbital are the lone-pair electrons of CH_3O^-?
A) *s*
B) *p*
C) *sp*
D) sp^2
E) sp^3
Answer: E
Diff: 2
Section: 1-14
Objective: G2, G3
LO: 1.17

51) Which of the following compounds <u>does not</u> have a dipole moment of zero?
A) CO_2
B) CH_4
C) CCl_4
D) H_2O
E) SO_3
Answer: D
Diff: 2
Section: 1-15
Objective: G2, G3
LO: 1.18

52) Which of the following compounds has a dipole moment of zero?
A)

B)

C)

D)

E)

Answer: B
Diff: 2
Section: 1-15
Objective: G2, G3
LO: 1.18

53) Which of the following compounds has the <u>smallest</u> dipole moment?
A) Br_2
B) NH_3
C) HCl
D) HBr
E) HI
Answer: A
Diff: 2
Section: 1-15
Objective: G2, G3
LO: 1.18

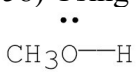
54) Which of the following compounds does not have a dipole moment of zero?
A) CH_3NH_2
B) CO_2
C) CH_3OCH_3
D) $(CH_3)_2C{=}C(CH_3)_2$
E) $CHCl_3$
Answer: E
Diff: 2
Section: 1-15
Objective: G2, G3
LO: 1.18

55) Atoms with the same number of protons but different numbers of neutrons are called _____.
Answer: isotopes
Diff: 1
Section: 1-1
Objective: G2, G3
LO: 1.1

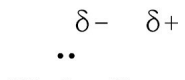
56) Ar, K^+, and Cl^- each have 18 electrons. What orbital does the highest-energy electron occupy?
Answer: a 3*p* orbital
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

57) What is the electronic configuration of Ca^{2+}?
Answer: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
Diff: 2
Section: 1-2
Objective: G2, G3
LO: 1.2

58) Using the symbols δ+ and δ-, show the direction of the polarity in the O-H bond.



Answer:



Diff: 3
Section: 1-3
Objective: G2, G3
LO: 1.4

59) What atomic property determines the polarity of a chemical bond?
Answer: electronegativity
Diff: 2
Section: 1-3
Objective: G2, G3
LO: 1.3

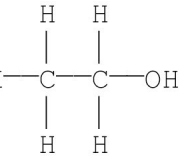
60) What two factors determine the size of a bond's dipole moment?
Answer: The size of the charge and the distance between the charges.
Diff: 3
Section: 1-3
Objective: G2, G3
LO: 1.3

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

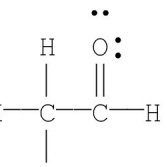
a. CH_3CH_2OH b. CH_3CHO c. $(CH_3)_3C^+$

Answer:

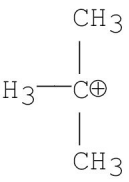
a.



b.

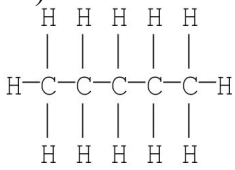


c.



Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.6

62) Convert the following Kekulé structure into a condensed structure.



Answer: $CH_3(CH_2)_3CH_3$ or $CH_3CH_2CH_2CH_2CH_3$

Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.6

63) Draw condensed structures for the four compounds with molecular formula C_3H_9N.

Answer: $CH_3CH_2CH_2NH_2$

$CH_3CH_2NHCH_3$

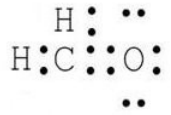
$(CH_3)_2CHNH_2$

$(CH_3)_3N$

Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.5

64) Draw the Lewis structure for CH_2CO.

Answer:

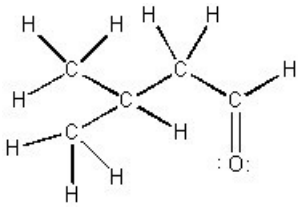


Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.5

65) Expand the condensed structure shown below to show the covalent bonds and the lone-pair electrons.

$(CH_3)_2CHCH_2CHO$

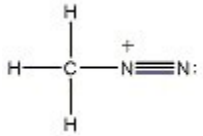
Answer:



Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.5

66) Draw the Lewis structure for $CH_3N_2^+$.

Answer:



Diff: 3
Section: 1-4
Objective: G2, G3
LO: 1.5

67) Draw a 2*p* orbital.
Answer:

Diff: 2
Section: 1-5
Objective: G2, G3
LO: 1.7

68) What orbitals are used to form the covalent bonds in $CH_3CH_2CH_2CH_3$?
Answer: The carbon-carbon σ bonds are formed by the overlap of an sp^3 orbital of each carbon. The carbon-hydrogen σ bonds are formed by the overlap of an sp^3 orbital of carbon with the *s* orbital of hydrogen.
Diff: 3
Section: 1-7
Objective: G2, G3
LO: 1.9

69)) Draw the structure of a compound that contains only carbon and hydrogen atoms and that has two sp^2 carbons and one *sp* carbon.
Answer: $H_2C{=}C{=}CH_2$
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.16

70) Why is the C—H bond in ethene ($H_2C{=}CH_2$) 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. The more *s* character in the 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* orbital. Ethene uses sp^2 orbitals (1/3 *s* character) to form its carbon-hydrogen bonds, whereas ethane uses sp^3 orbitals (1/4 *s* character).
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.16

71) 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
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.16

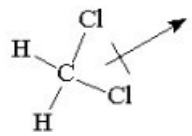
72) What is the hybridizations of the carbons, going from left to right, in $CH_3CH{=}CHCl$?
Answer: sp^3, sp^2, sp^2
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.17

73) What is the hybridization and bond angles of the carbon in CO_2?
Answer: *sp*, linear, 180
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.17

74) What is the hybridization and bond angles of each carbon in CH_3CN?
Answer: CH_3 - sp^3, 109.5; C - *sp*, 180
Diff: 3
Section: 1-14
Objective: G2, G3
LO: 1.17

75) What is the hybridization of the nitrogen in $(CH_3)_3N$?
Answer: sp^3
Diff: 2
Section: 1-14
Objective: G2, G3
LO: 1.17

76) Draw the Kekulé structure of CH_2Cl_2 and show the direction of its dipole moment.
Answer:



Diff: 3
Section: 1-15
Objective: G2, G3

LO: 1.18