

Organic Chemistry, 8e (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?

$1s^2 2s^2 2p^5$

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) $1s^2 2s^2$
- 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

Section: 1-2

9) Give the electronic configuration for Ca^{+2} .

Answer: $1s^2 2s^2 2p^6 3s^2 3p^6$

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 lone pairs of electrons in H_2NOH .

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

Answer: D

Section: 1-4

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

MCAT: 1.2

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

MCAT: 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

MCAT: 1.3

GLO: G2

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

MCAT: 1.3

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

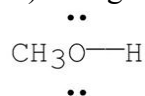
- A) C-C
- B) C-H
- C) C-O
- D) H-N
- E) H-F

Answer: E

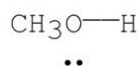
Section: 1-3

MCAT: 2.6, 6.4

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



Answer:



Section: 1-3

MCAT: 2.6

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

Answer: electronegativity

Section: 1-3

MCAT: 1.5

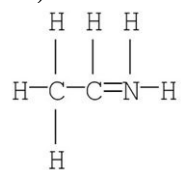
19) Provide the mathematical equation for the dipole moment of a bond, and identify the variables.

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

MCAT: 1.5

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



A) +2

B) +1

C) 0

D) -1

E) -2

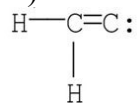
Answer: B

Section: 1-4

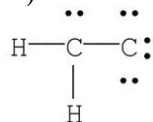
MCAT: 1.2

21) Which of the following is the most likely electronic structure for C_2H_2 ?

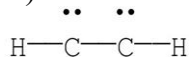
A)



B)

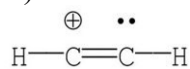


C)



D) $\text{H}-\text{C}\equiv\text{C}-\text{H}$

E)

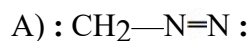


Answer: D

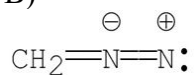
Section: 1-4

MCAT: 1.2, 2.1, 2.2

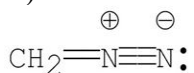
22) Which of the following structures, including formal charges, is correct for diazomethane, CH_2N_2 ?



B)



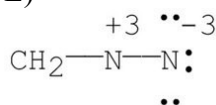
C)



D)



E)

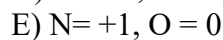
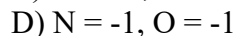
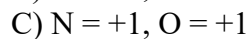
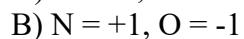
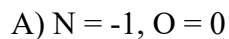
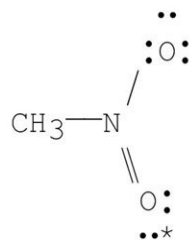


Answer: D

Section: 1-4

MCAT: 1.2, 2.1

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



Answer: E

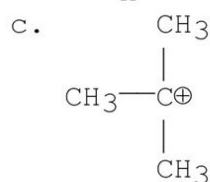
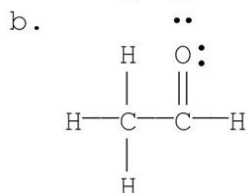
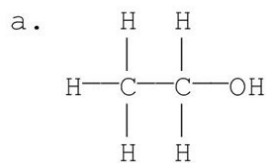
Section: 1-4

MCAT: 2.1

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

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

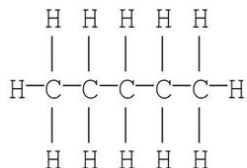
Answer:



Section: 1-4

MCAT: 1.2, 2.1

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

26) Draw condensed structures for the four compounds with formula $\text{C}_3\text{H}_9\text{N}$.

Answer: $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$

$\text{CH}_3\text{CH}_2\text{NHCH}_3$

$(\text{CH}_3)_2\text{CHNH}_2$

$(\text{CH}_3)_3\text{N}$

Section: 1-4

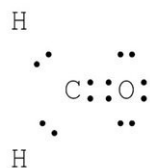
MCAT: 1.1

GLO: G2

27) Draw a Lewis structure for the molecule given and show all formal charges.

CH_2CO

Answer:



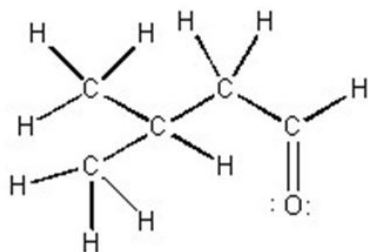
Section: 1-4

MCAT: 1.2, 2.1

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

$(\text{CH}_3)_2\text{CHCH}_2\text{CHO}$

Answer:

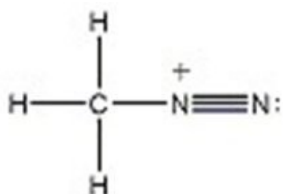


Section: 1-4

MCAT: 1.2, 2.1

29) Draw the Lewis structure for CH_3N_2^+ .

Answer:



Section: 1-4

MCAT: 1.2, 2.1

30) Give the formal charge on nitrogen in NH_4 .

A) -2

B) -1

C) 0

D) +1

E) +2

Answer: D

Section: 1-4

MCAT: 1.2

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

MCAT: 2.7, 7.5, 9.3, 14.3, 15.1

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

MCAT: 2.7, 7.5, 9.3, 14.3

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

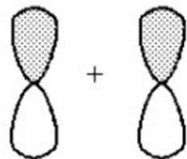


Answer: σ

Section: 1-6

MCAT: 2.7, 7.5, 9.3, 14.3

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

MCAT: 2.7, 7.5, 9.3, 14.3

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

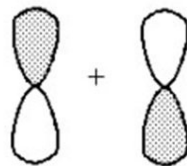


Answer: σ^*

Section: 1-6

MCAT: 2.7, 7.5, 9.3, 14.3

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

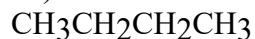


Answer: π^*

Section: 1-6

MCAT: 2.7, 7.5, 9.3, 14.3

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



↑

A) sp

B) sp^2

C) sp^3

D) none of the above

Answer: C

Section: 1-7

MCAT: 2.2

41) What orbitals are used to form the covalent bonds in butane ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$)?

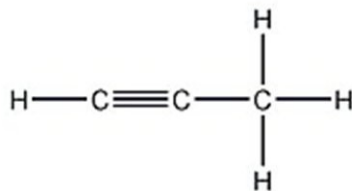
Answer: The carbon-carbon σ bonds are formed by the overlap of two carbon sp^3 hybrid atomic orbitals. The carbon-hydrogen σ bonds are formed by the overlap of a carbon sp^3 hybrid atomic orbital and a hydrogen s orbital.

Section: 1-7

MCAT: 2.7, 7.5, 9.3, 14.3

GLO: G2

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



A) 1

B) 2

C) 3

D) 4

Answer: B

Section: 1-9

MCAT: 2.7, 7.5, 9.3, 14.3

43) A molecule of acetonitrile CH_3CN contains _____ sigma bonds and _____ pi bonds.

A) 5, 2

B) 4, 3

C) 4, 2

D) 2, 2

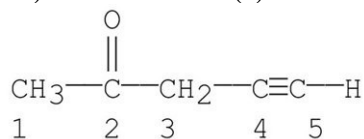
E) 4, 0

Answer: A

Section: 1-9

MCAT: 2.7, 7.5, 9.3, 14.3

44) Which carbon(s) in the following molecule is (are) sp hybridized?



- A) carbon 1
- B) carbon 2
- C) carbons 1, 3
- D) carbons 4
- E) carbons 4, 5

Answer: E

Section: 1-9

MCAT: 2.2

45) Determine the number of pi bonds in CH₃CN.

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

Answer: C

Section: 1-9

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

46) How many sp² hybridized carbons are present in allene (H₂C=C=CH₂)?

- A) 0
- B) 1
- C) 1.5
- D) 2
- E) 3

Answer: D

Section: 1-9

MCAT: 2.2

47) What orbitals overlap to create the C-H bond in ethene (H₂C=CH₂)?

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

Answer: B

Section: 1-10

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

GLO: G2

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

A)



B) $\cdot CH_3$

C)



D) A and B

E) A, B and C

Answer: A

Section: 1-18

MCAT: 2.2, 4.2

49) What is the predicted shape, bond angle, and hybridization for $^+CH_3$?

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

MCAT: 2.2

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

MCAT: 4.2

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

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

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

MCAT: 2.2

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

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

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

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

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

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

56) Which of the following is closest to the C-O-C bond angle in $\text{CH}_3\text{-O-CH}_3$?

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

Answer: C

Section: 1-14

MCAT: 2.2

57) Each lone pair of electrons on the O atom in methanol (CH_3OH) occupies a(n) _____ orbital.

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

Answer: E

Section: 1-12

MCAT: 2.2

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

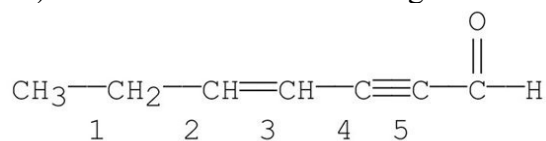
59) The hydrogen-halogen bond becomes _____ and _____ as the size (atomic weight) of the halogen increases.

- 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?

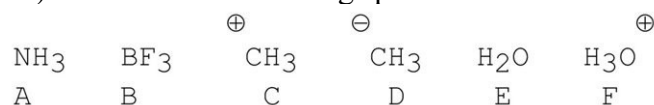


- A) bond 1
- B) bond 2
- C) bond 3
- D) bond 4
- E) bond 5

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: 1-14

MCAT: 2.2, 4.2

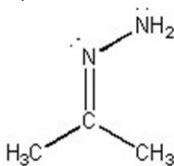
62) The carbon-carbon double bond in ethene is _____ and _____ than the carbon-carbon triple bond in ethyne.

- 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: 1-14

MCAT: 2.2

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: $H_2C=C=CH_2$

Section: 1-15

MCAT: 2.2, 2.7, 7.5, 9.3, 14.3

GLO: G2

65) 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 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

GLO: G2

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: 1-14

MCAT: 9.3

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: 1-14

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

MCAT: 2.2

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

MCAT: 2.2

GLO: G2

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

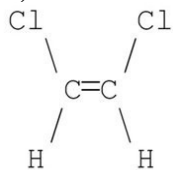
Answer: D

Section: 1-16

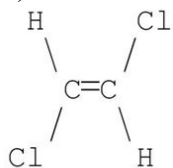
MCAT: 2.6

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

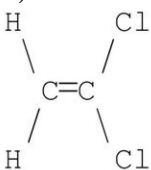
A)



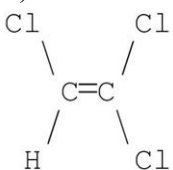
B)



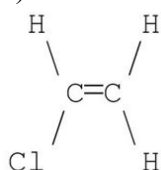
C)



D)



E)



Answer: B

Section: 1-16

MCAT: 2.6

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

A) Br₂

B) NH₃

C) HCl

D) HBr

E) HI

Answer: A

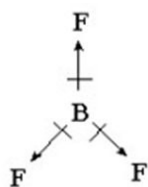
Section: 1-16

MCAT: 2.5, 6.4

GLO: G2

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

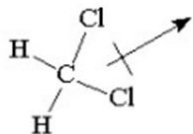
Answer: BF_3 is trigonal planar.



Section: 1-16

MCAT: 2.2, 2.5

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



Answer:

Section: 1-16

MCAT: 2.2, 2.5

81) Identify the compound(s) that have a nonzero dipole moment. You may choose more than one answer.

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

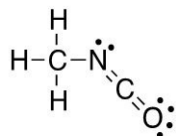
Answer: A, C

Section: 1-16

MCAT: 2.2, 2.5

82) In 2015, the European Space Agency's Philae Lander detected the presence of methylisocyanate CH_3NCO on the comet 67P. Draw the Lewis structure of this compound, showing all lone pairs.

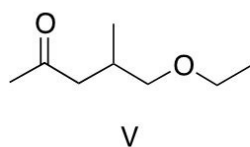
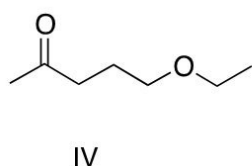
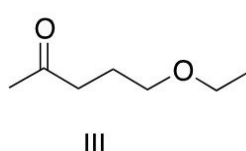
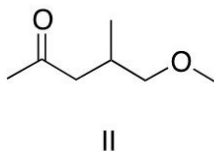
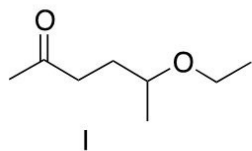
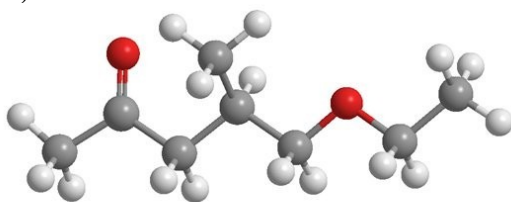
Answer:



Section: 1-4

MCAT: 2.2

83) Convert the model below into skeletal structure.

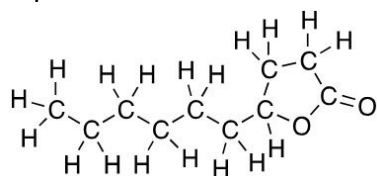


- A) I
- B) II
- C) III
- D) IV
- E) V

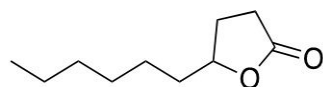
Answer: E

Section: 1-4

84) Several volatile compounds are responsible for the aroma of plums. One of these compounds is γ -decalactone whose Kekulé structure is shown below. Convert it into a skeletal structure.



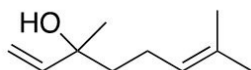
Answer:



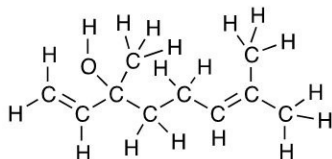
Section: 1-4

GLO: G7

85) Several volatile compounds are responsible for the aroma of plums. One of these compounds is linalool whose skeletal structure is shown below. Convert it into Kekulé structure.



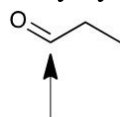
Answer:



Section: 1-4

GLO: G7

86) Propanal is a compound detected on the surface of comet 67P by the Philae Lander. How many hydrogen atoms are present at the indicated carbon?



A) 0

B) 1

C) 2

D) 3

E) 4

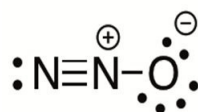
Answer: B

Section: 1-4

MCAT: 2.2

87) Nitrous oxide N_2O , also known as laughing gas is often used in surgery and dentistry for its anesthetic and analgesic effects. Draw its Lewis structure?

Answer:



Section: 1-4

MCAT: 2.2

GLO: G7

88) The lobes of the p-orbital are often designated by "+" and "-" signs as shown. What do these signs represent?

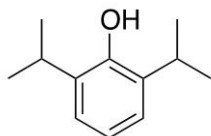


- A) opposite charges
- B) phases of the orbital
- C) positive indicates the location of protons and negative indicates the location of electrons
- D) that the orbital has polarity
- E) all of the above

Answer: B

Section: 1-5

89) The structure of a widely used anesthetic propofol is given below. How many sp^3 hybridized atoms are in this molecule?



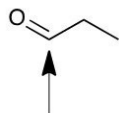
- A) 1
- B) 3
- C) 5
- D) 6
- E) 9

Answer: D

Section: 1-15

MCAT: 2.2

90) Propanal is a compound detected on the surface of comet 67P by the Philae Lander. How many sp^2 hybridized atoms are in this molecule?



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

Answer: C

Section: 1-15

MCAT: 2.2