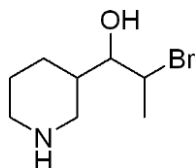


1. Which is the most electronegative atom in the compound below?



- A) Carbon C) Oxygen
B) Nitrogen D) Bromine

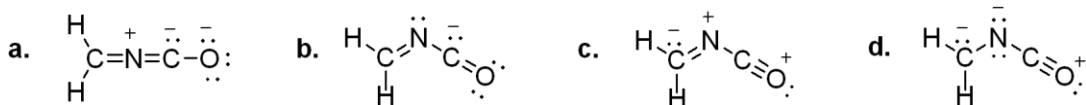
2. Which of the following correctly describes the electrons of a carbon atom in its ground state?

- A) 3 *s* electrons; 3 *p* electrons
B) 2 1*s* electrons; 4 2*p* electrons
C) 2 1*s* electrons; 2 2*s* electrons; 2 2*p* electrons
D) 2 1*s* electrons; 2 2*s* electrons; 4 2*p* electrons
E) None of these choices is correct.

3. Which of the following statements correctly describes the typical bonding of carbon, nitrogen, and oxygen in organic molecules?

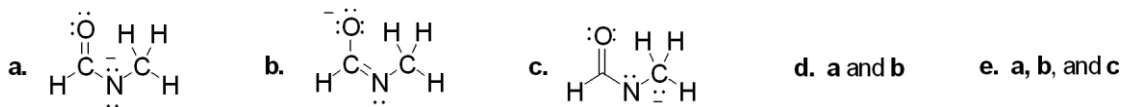
- A) Carbon participates in 4 covalent bonds, oxygen participates in 2 covalent bonds and nitrogen participates in 5 covalent bonds.
B) Carbon participates in 3 covalent bonds, oxygen participates in 2 covalent bonds and nitrogen participates in 5 covalent bonds.
C) Carbon participates in 4 covalent bonds, oxygen participates in 3 covalent bonds and nitrogen participates in 3 covalent bonds.
D) Carbon participates in 3 covalent bonds, oxygen participates in 3 covalent bonds and nitrogen participates in 5 covalent bonds.
E) Carbon participates in 4 covalent bonds, oxygen participates in 2 covalent bonds and nitrogen participates in 3 covalent bonds.

4. Which is *not* an acceptable Lewis structure for the anion $(\text{CH}_2\text{NCO})^-$?



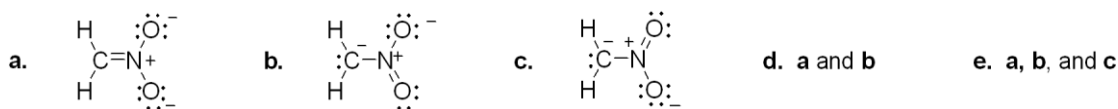
- A) a B) b C) c D) d

5. Which of the following is (are) valid Lewis structure(s) for the anion $(\text{HCONCH}_3)^-$?



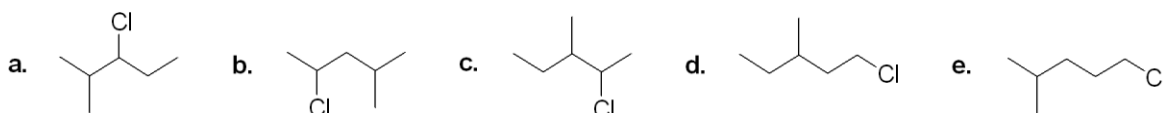
- A) a B) b C) c D) d E) e

6. Which of the following is (are) valid Lewis structure(s) for the anion $(\text{CH}_2\text{NO}_2)^-$?
Assume the atoms are arranged as drawn.



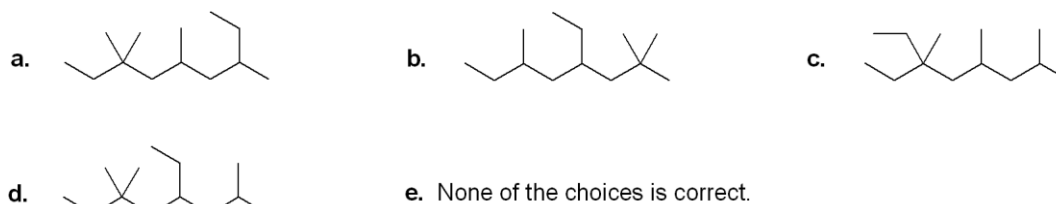
A) a B) b C) c D) d E) e

7. Which is the appropriate conversion of $\text{CH}_3\text{CHClCH}_2\text{CH}(\text{CH}_3)_2$ to a skeletal formula?



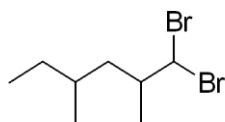
A) a B) b C) c D) d E) e

8. Convert the following compound from a condensed formula to a skeletal formula:
 $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}_2\text{CH}(\text{CH}_3)_2$.



A) a B) b C) c D) d E) e

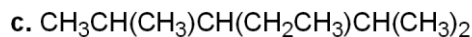
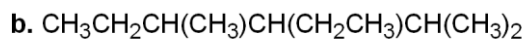
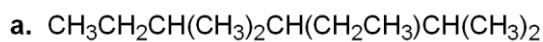
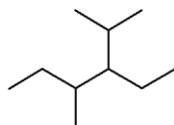
9. What is the condensed formula of the compound below?



- a. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}(\text{CH}_3)\text{CHBr}_2$
b. $\text{CH}_3\text{CH}_2\text{CH}_2(\text{CH}_3)\text{CH}_2\text{CH}(\text{CH}_3)\text{CHBr}_2$
c. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{CH}_2\text{CHBr}_2$

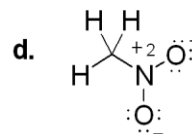
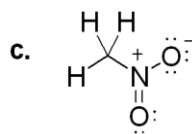
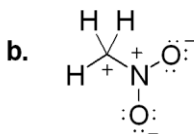
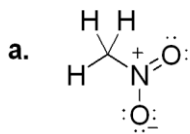
A) a B) b C) c

10. Convert the following skeletal formula to a condensed formula.



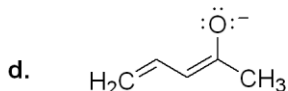
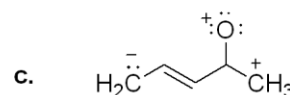
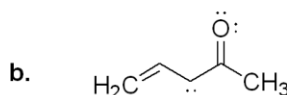
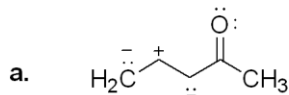
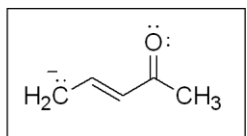
A) a B) b C) c

11. Which of the following is *not* a valid Lewis structure of CH_3NO_2 ?



A) a B) b C) c D) d

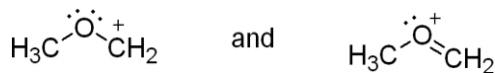
12. Which is *not* a valid resonance structure for the anion below?



e. All are valid resonance structures.

A) a B) b C) c D) d E) e

13. How are the molecules in the following pair related?



A) They are constitutional isomers.

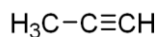
B) They are resonance structures.

C) They represent the same structure.

14. How are the molecules in the following pair related?



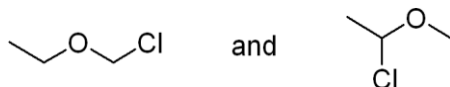
and



A) They are constitutional isomers.

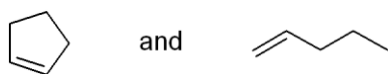
- B) They are resonance structures.
 C) Neither of the choices is correct.

15. How are the molecules in the following pair related?



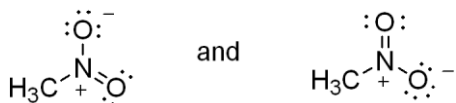
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) Neither of the choices is correct.

16. How are the molecules in the following pair related?



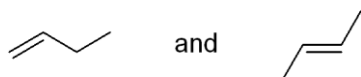
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) They are unrelated molecules.

17. How are the molecules in the following pair related?



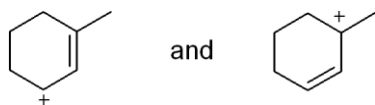
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) Neither of the choices is correct.

18. How are the molecules in the following pair related?



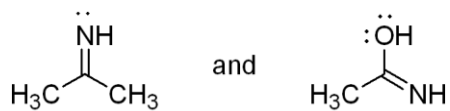
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) Neither of the choices is correct.

19. How are the molecules in the following pair related?



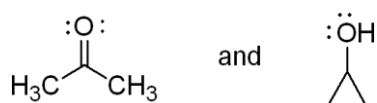
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) Neither of the choices is correct.

20. How are the molecules in the following pair related?



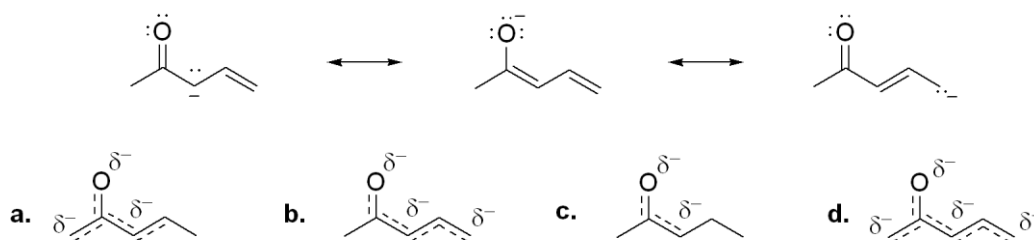
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) They are unrelated molecules.

21. How are the molecules in the following pair related?



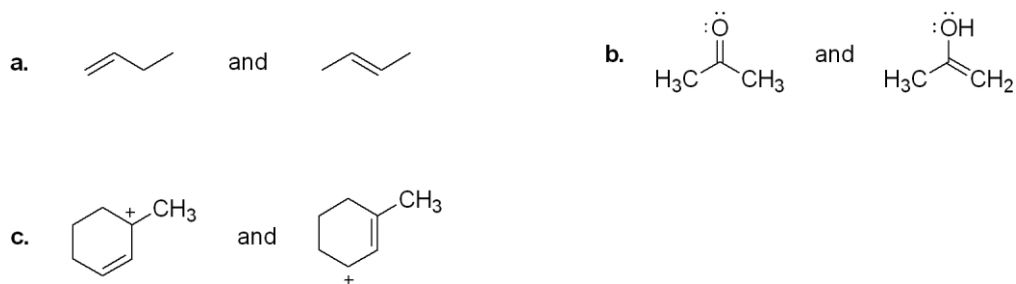
- A) They are constitutional isomers.
 B) They are resonance structures.
 C) Neither of the choices is correct.

22. Which is the most accurate representation of the resonance hybrid for the resonance structures shown below?



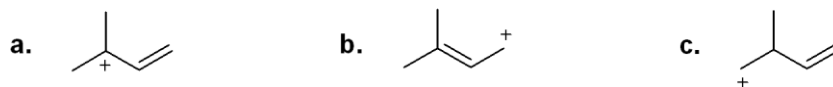
- e. None of the choices is correct.
 A) a B) b C) c D) d E) e

23. Which of the following pairs of compounds are resonance structures?



- A) a B) b C) c

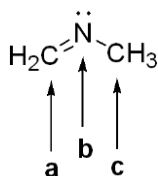
24. Which of the following structures are resonance structures of each other?



- A) a and b

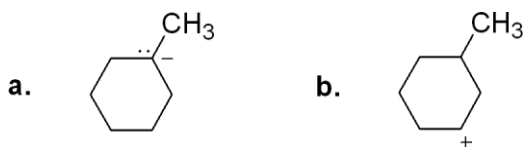
- B) b and c
 C) a and c
 D) All are resonance structures.
 E) None of these are resonance structures.

25. What is the hybridization for each of the indicated atoms in the following compound?



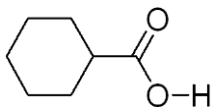
- A) **a** - sp^2 ; **b** - sp^2 ; **c** - sp^2
 B) **a** - sp^2 ; **b** - sp^3 ; **c** - sp^3
 C) **a** - sp ; **b** - sp^2 ; **c** - sp^3
 D) **a** - sp^2 ; **b** - sp^2 ; **c** - sp^3

26. Indicate the hybridization of the carbon ion in each compound below.



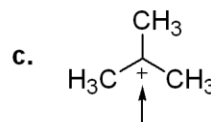
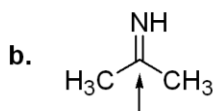
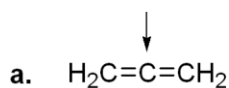
- A) **a** - sp^2 ; **b** - sp^2 C) **a** - sp^3 ; **b** - sp^3
 B) **a** - sp^2 ; **b** - sp^3 D) **a** - sp^3 ; **b** - sp^2

27. Consider the organic molecule drawn below. Describe which orbitals are used to form the C=O bond. Since there are two bonds, you must identify two different sets of orbitals.



- A) $C_{sp^2} - O_{sp^2}$ and $C_s - O_p$
 B) $C_{sp} - O_{sp}$ and $C_p - O_p$
 C) $C_{sp^2} - O_{sp^2}$ and $C_s - O_s$
 D) $C_{sp^3} - O_{sp^2}$ and $C_p - O_p$
 E) $C_{sp^2} - O_{sp^2}$ and $C_{2p} - O_{2p}$

28. Which of the following compounds has a labeled carbon atom that is sp^2 hybridized?

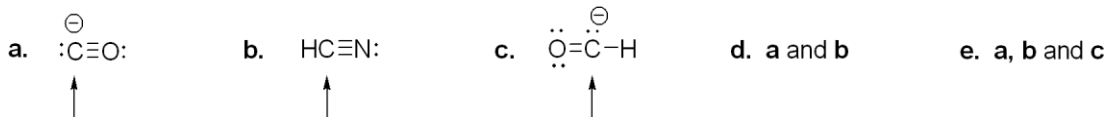


d. Compounds **b** and **c**

e. **a**, **b** and **c** all have sp^3 hybridized carbon.

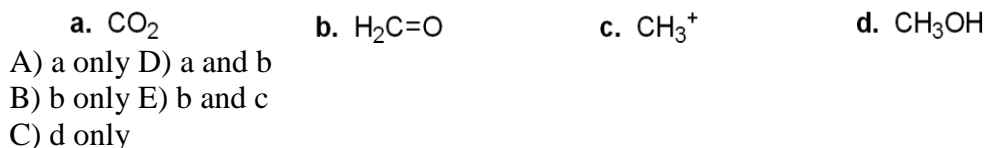
A) a B) b C) c D) d E) e

29. Which of the following compounds contains a labeled atom that is sp hybridized?
(All nonbonded electron pairs have been drawn in.)

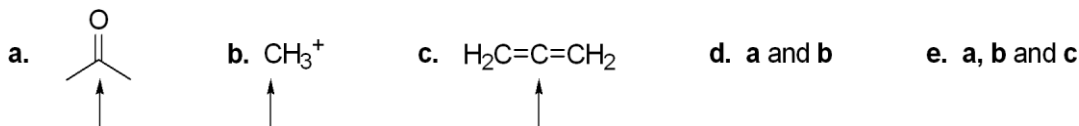


A) a B) b C) c D) d E) e

30. Which of the compounds drawn below contains an sp^2 hybridized carbon atom?
Select any and all structures that apply.

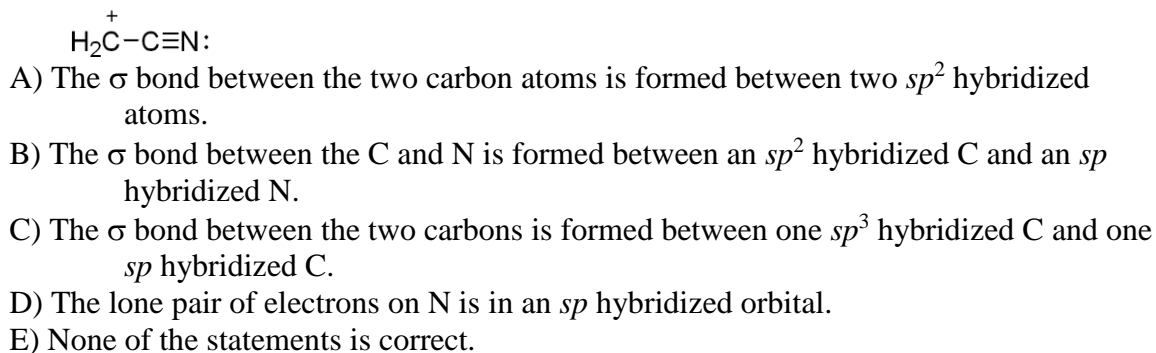


31. Which of the labeled carbon atoms is (are) sp^2 hybridized?

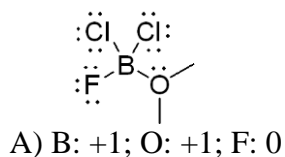


A) a B) b C) c D) d E) e

32. Which statement best describes the orbital hybridization used to form bonds in the cation below?

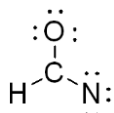


33. Indicate the formal charge on the B, O, and F atoms in the following compound.



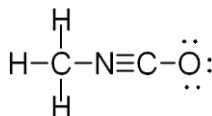
- B) B: -1; O: -1; F: 0
 C) B: +1; O: -1; F: 0
 D) B: -1; O: +1; F: 0
 E) None of the choices is correct.

34. In the following compound, indicate the formal charge on all atoms except hydrogen.



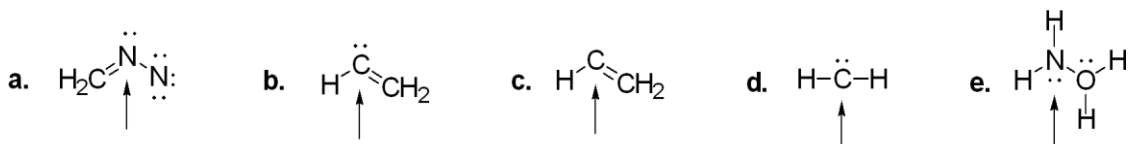
- A) Carbon +1; Oxygen +1; Nitrogen -2
 B) Carbon -1; Oxygen +1; Nitrogen -2
 C) Carbon +1; Oxygen -1; Nitrogen -2
 D) Carbon +1; Oxygen -1; Nitrogen -1
 E) None of the choices is correct.

35. In the following compound, indicate the formal charge on all atoms except hydrogen, from left to right.



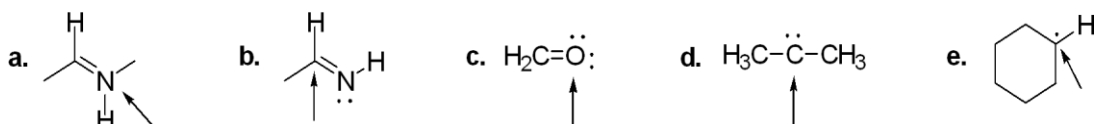
- A) Carbon 0; Nitrogen -1; Carbon +1; Oxygen 0
 B) Carbon -0; Nitrogen -1; Carbon 0; Oxygen -1
 C) Carbon 0; Nitrogen -1; Carbon 0; Oxygen -1
 D) Carbon 0; Nitrogen +1; Carbon 0; Oxygen -1
 E) None of the choices is correct.

36. Which of the following compounds has a labeled atom with a +1 formal charge? (All nonbonded electron pairs have been drawn in.)



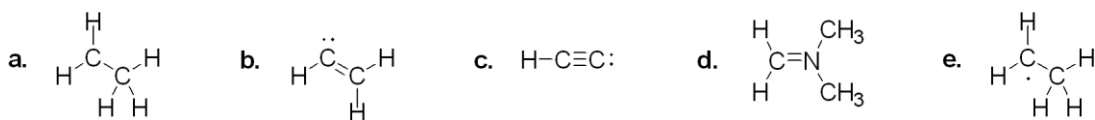
- A) a B) b C) c D) d E) e

37. Which of the following species has a labeled atom with a +1 formal charge? (All nonbonded electron pairs have been drawn in.)



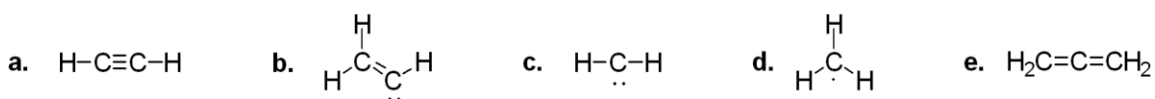
- A) a B) b C) c D) d E) e

38. Which of the following species contains a carbon atom with a +1 formal charge? (All nonbonded electron pairs have been drawn in.)



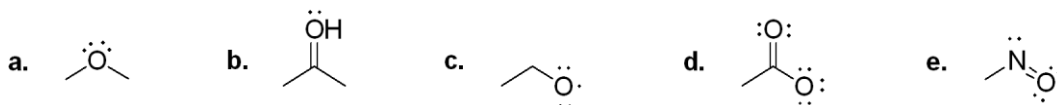
A) a B) b C) c D) d E) e

39. Which of the following species contains a carbon atom with a -1 formal charge? (All nonbonded electron pairs have been drawn in.)



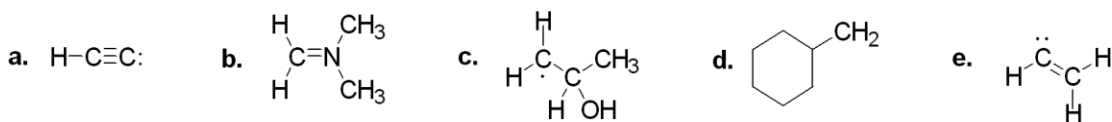
A) a B) b C) c D) d E) e

40. Which of the following species contains an O atom with a +1 formal charge? (All nonbonded electron pairs have been drawn in.)



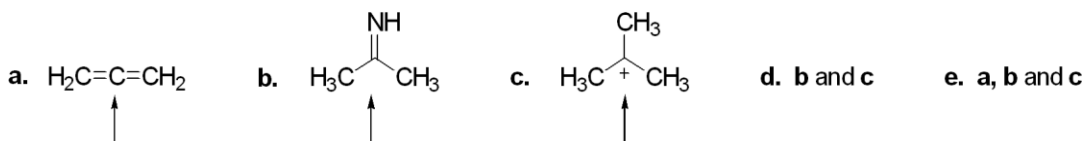
A) a B) b C) c D) d E) e

41. Which of the following species contains a carbon atom with a +1 formal charge? (All nonbonded electrons and electron pairs have been drawn in.)



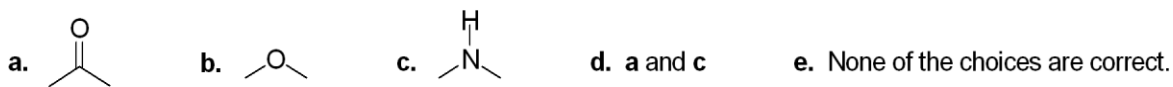
A) a B) b C) c D) d E) e

42. Which of the following species has (have) a trigonal planar structure with 120° bond angles around the labeled carbon atom?



A) a B) b C) c D) d E) e

43. Which of the following molecules has (have) a trigonal planar geometry?



A) a B) b C) c D) d E) e

44. Which of the following compounds possess(es) a nitrogen with tetrahedral geometry?

A) $\text{CH}_3\text{C}\equiv\text{N}$:

B) NH_2^-

C) NH_4^+

D) $\text{CH}_3\text{C}\equiv\text{N}$: and NH_2^- are both tetrahedral.

E) NH_2^- and NH_4^+ are both tetrahedral.

45. Which of the following molecules is (are) polar?

a. CH_3Cl

b. CH_2Cl_2

c. CCl_4

A) a D) a and b

B) b E) b and c

C) c

46. Which of the following statements is (are) correct?

A) Ethane has sp^3 carbon atoms and the geometry around each carbon is trigonal planar.

B) Ethane has sp^3 carbon atoms and the geometry around each carbon is tetrahedral.

C) Ethane has sp^2 carbon atoms and the geometry around each carbon is tetrahedral.

D) Ethane has sp^2 carbon atoms and the geometry around each carbon is trigonal planar.

E) None of the statements are correct.

47. Which of the following statements is (are) correct?

A) The carbon-carbon distance in acetylene is longer than in ethylene.

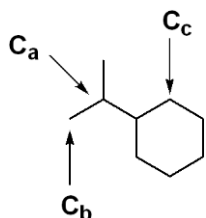
B) The carbon-hydrogen bond in acetylene is weaker than the carbon-hydrogen bond in ethane.

C) The carbon-carbon distance in acetylene is shorter than in ethane.

D) The statements (The carbon-carbon distance in acetylene is longer than in ethylene) and (The carbon hydrogen bond in acetylene is weaker than the carbon hydrogen bond in ethane) are correct.

E) The statements (The carbon hydrogen bond in acetylene is weaker than the carbon hydrogen bond in ethane) and (The carbon-carbon distance in acetylene is shorter than in ethane) are correct.

48. How many hydrogens are directly bonded to each of the indicated carbon atoms?



- A) C_a 1; C_b 3; C_c 2
- B) C_a 2; C_b 3; C_c 2
- C) C_a 1; C_b 2; C_c 2
- D) C_a 1; C_b 3; C_c 3
- E) None of the choices is correct.

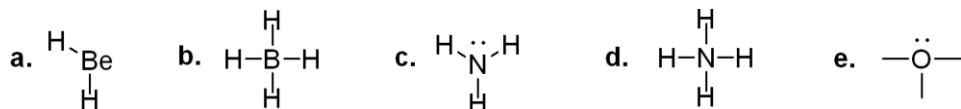
49. Of the molecules listed, which does *not* have a dipole moment?

- A) HCl
- B) NCl₃
- C) CO
- D) BF₃
- E) All molecules have a dipole moment.

50. For the elements Rb, F, and O, the order of increasing electronegativity is:

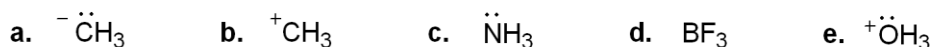
- A) Rb < F < O
- B) Rb < O < F
- C) O < F < Rb
- D) F < Rb < O
- E) The order cannot be determined.

51. Which of the following Lewis dot structure(s) below bear(s) a positive charge?



- A) a D) c and d
- B) b E) d and e
- C) c

52. Which of the following species has (have) a trigonal planar structure?



- A) a, b, and c
- B) b and d
- C) d
- D) b, d, and e
- E) All of the choices are correct.

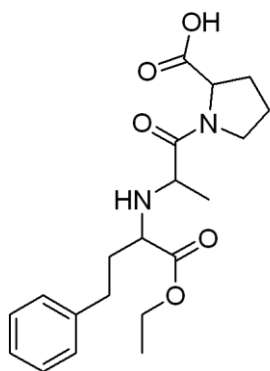
53. What is the molecular shape of methyl anion?



- A) Octahedral
- B) Tetrahedral
- C) Trigonal planar
- D) Trigonal pyramidal
- E) Linear

Challenge Questions

54. **Enalapril** is currently in clinical trials for congestive heart failure, and its structure is given below. What is the correct molecular formula for this interesting antihypertensive agent?

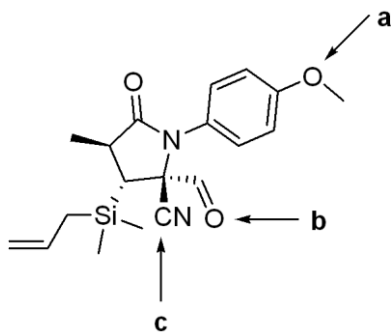


- a. $C_{20}H_{28}N_2O_5$ d. $C_{20}H_{26}N_2O_5$
 b. $C_{18}H_{26}N_2O_5$ e. $C_{18}H_{25}N_2O_5$
 c. $C_{16}H_{24}N_2O_5$

Enalapril

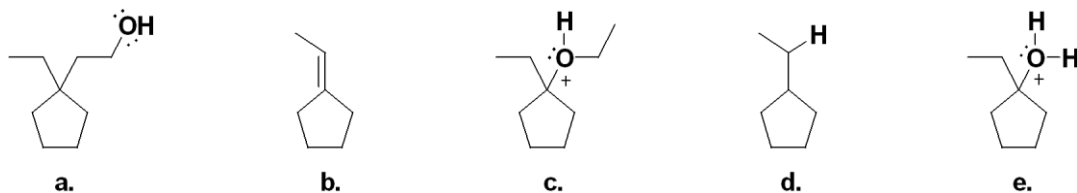
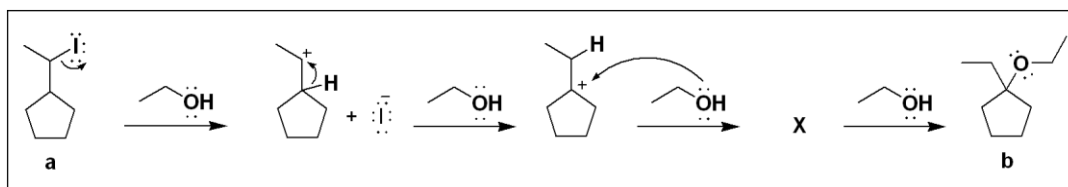
- A) a B) b C) c D) d E) e

55. The following compound is a synthetic intermediate in the production of **lactacystin**. Identify the orbital hybridization and geometry of the atoms next to the three arrows.



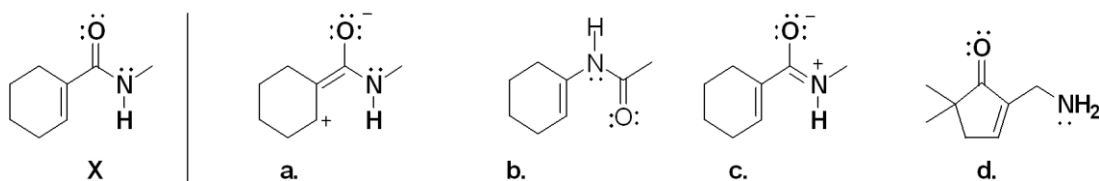
- A) **a** – sp^3 ; **b** – sp^2 ; **c** – sp^3
 B) **a** – sp^2 ; **b** – sp ; **c** – sp^3
 C) **a** – sp^2 ; **b** – sp^3 ; **c** – sp^2
 D) **a** – sp^3 ; **b** – sp^2 ; **c** – sp
 E) None of the choices is correct.

56. The following scheme represents an S_N1 mechanism for the conversion of alkyl halide “**a**” to ether “**b**.” Determine the correct structure for intermediate “**X**” based on the curved arrow formalism shown.



A) a B) b C) c D) d E) e

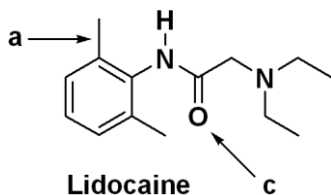
57. With reference to compound **X** drawn below, label each compound as an isomer, a resonance structure or neither.



- A) **a**. resonance structure; **b**. isomer; **c**. neither; **d**. isomer
 B) **a**. isomer; **b**. resonance structure; **c**. isomer; **d**. neither
 C) **a**. isomer; **b**. neither; **c**. isomer; **d**. resonance structure
 D) **a**. resonance structure; **b**. isomer; **c**. resonance structure; **d**. isomer
 E) None of the choices are correct.

Use the following to answer questions 58-60.

Answer the following questions about **lidocaine**, a commonly used dental anesthetic.



58. What orbitals are used to form the bond indicated by **a**?

- A) Csp^2-Csp^2 D) Csp^-Csp^2
 B) Csp^3-Csp^2 E) Csp^3-Csp
 C) Csp^2-Csp

59. How many carbon atoms have sp^2 hybridization?

- A) 7 D) 10
 B) 5 E) 8

C) 6

60. Predict the geometry around the oxygen atom indicated by arrow c.

- A) Linear
- B) Tetrahedral
- C) Trigonal bipyramidal
- D) Trigonal planar
- E) Square planar

Answer Key - Chapter 1: Structure and Bonding

- 1. C
- 2. C
- 3. E
- 4. C
- 5. D
- 6. E
- 7. B
- 8. D
- 9. A
- 10. B
- 11. B
- 12. C
- 13. B
- 14. A
- 15. A
- 16. C
- 17. B
- 18. A
- 19. B
- 20. C
- 21. A
- 22. B
- 23. B
- 24. A
- 25. D
- 26. D
- 27. E
- 28. D
- 29. D
- 30. E
- 31. D
- 32. D
- 33. D
- 34. C
- 35. D

- 36. C
- 37. A
- 38. A
- 39. B
- 40. B
- 41. D
- 42. D
- 43. A
- 44. E
- 45. D
- 46. B
- 47. C
- 48. A
- 49. D
- 50. B
- 51. E
- 52. B
- 53. D
- 54. A
- 55. D
- 56. C
- 57. D
- 58. B
- 59. A
- 60. D