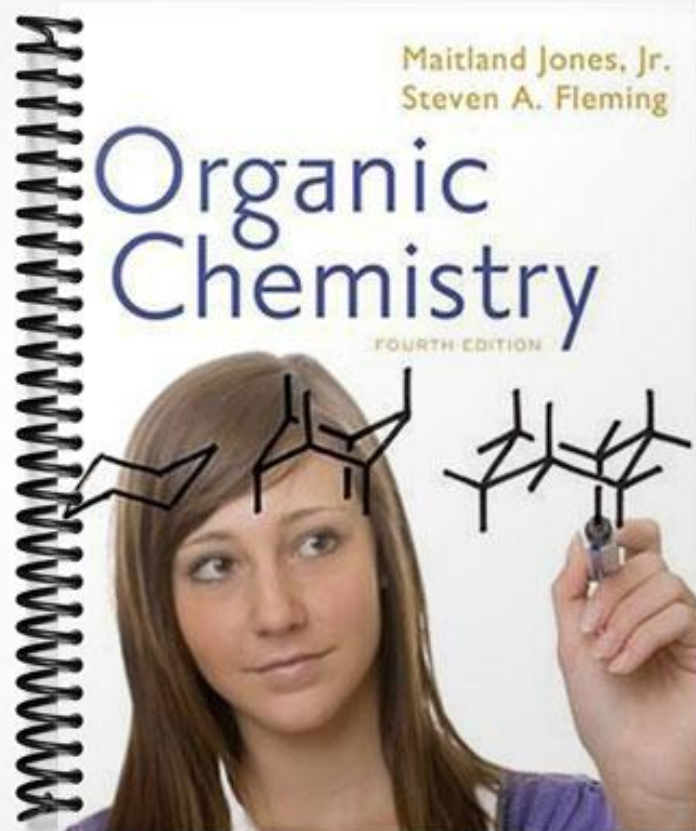


TEST BANK

Maitland Jones, Jr.
Steven A. Fleming

Organic
Chemistry
FOURTH EDITION



Chapter 2: Alkanes

MULTIPLE CHOICE

1. Which of the following orbitals is properly described as an antibonding orbital?

- a. $sp + 1s$
- b. $sp^2 + 1s$
- c. $sp^3 + 1s$
- d. $sp^2 - 1s$
- e. $sp^2 + sp^2$

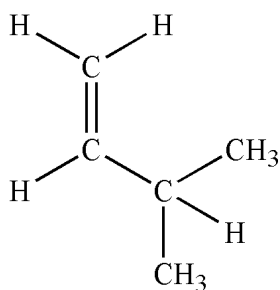
ANS: D

DIF: Easy

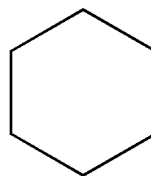
REF: 2.2

2. Which of the following structures contains a hybrid orbital with the *greatest* amount of *s* character?
(Assume approximate hybridization for all carbon atoms.)

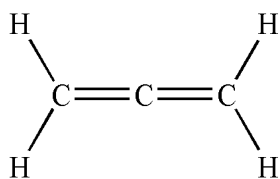
a.



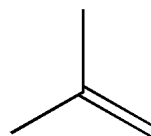
d.



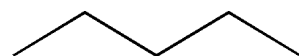
b.



e.



c.



ANS: B

DIF: Easy

REF: 2.2

3. Which of the following statements about methane, CH_4 , is *false*?

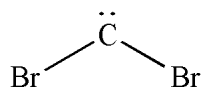
- a. The carbon–hydrogen bonds in methane are formed by the combination of an sp^3 orbital on carbon and a $1s$ orbital on hydrogen.
- b. The C–H bonding molecular orbital has cylindrical symmetry.
- c. The C–H antibonding molecular orbital does not have cylindrical symmetry.
- d. The hybrid orbitals on carbon are 25% *s* character and 75% *p* character.
- e. All bond angles are 109.5° .

ANS: C

DIF: Medium

REF: 2.2

4. Dibromocarbene is an example of a chemical species called a carbene:



Chapter 2

Carbenes exist in one of two forms. In one of these forms, called a singlet, both the nonbonding electrons on carbon occupy the same orbital. Approximately what type of orbital does the lone pair occupy?

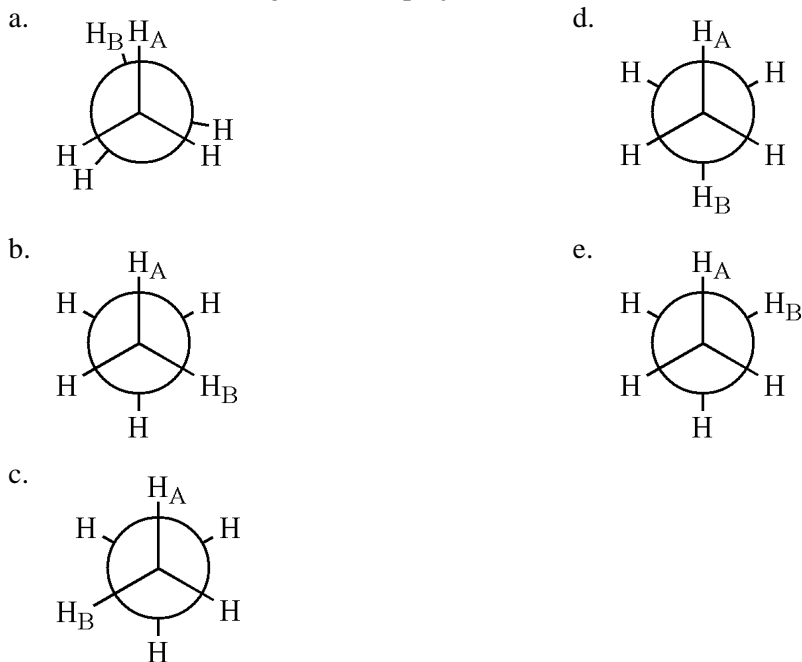
- a. sp
- b. sp^2
- c. sp^3
- d. $2s$
- e. $2p$

ANS: B DIF: Difficult REF: 2.2

5. Assuming an approximate sp^3 hybridization for nitrogen, which of the following statements about the molecular orbital diagram for pyramidal ammonia, NH_3 , is *false*?
- a. There is one nonbonding molecular orbital.
 - b. There are three bonding molecular orbitals.
 - c. There are three antibonding molecular orbitals.
 - d. All bonding orbitals are occupied.
 - e. All nonbonding orbitals are unoccupied.

ANS: E DIF: Difficult REF: 2.2

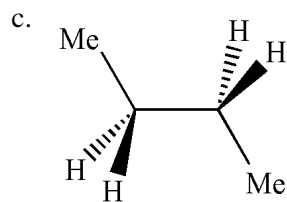
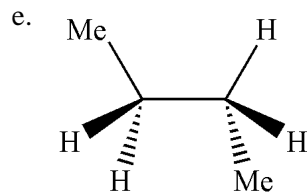
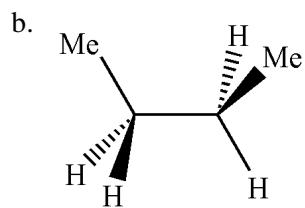
6. Which of the following Newman projections shows a dihedral angle of 60° between H_A and H_B ?



ANS: E DIF: Easy REF: 2.5

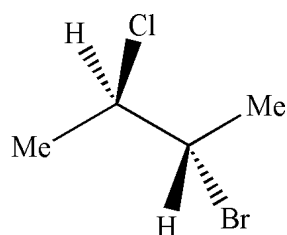
7. Which of the following structures is in the *gauche* butane conformation?



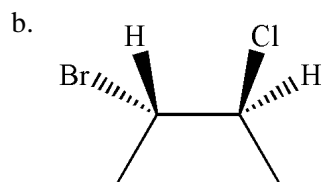
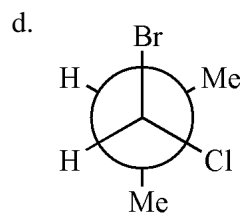
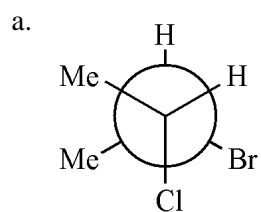


ANS: B DIF: Medium REF: 2.5

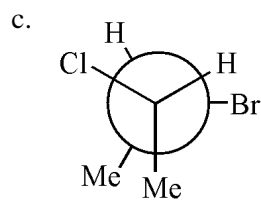
8. Which of the following structures is the same as structure A?



Structure A



e. None of these structures is the same as structure A.



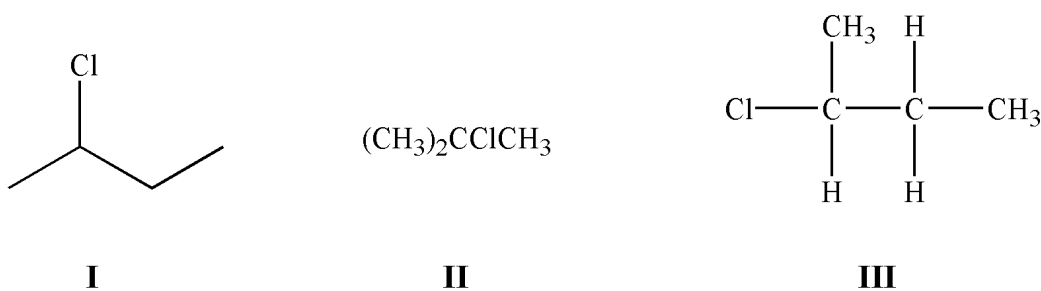
ANS: A DIF: Difficult REF: 2.5

Chapter 2

9. Which of the following statements about ethane is *false*?
- Staggered ethane is destabilized by interactions between filled C—H σ and empty C—H σ^* orbitals.
 - Staggered ethane is stabilized by interactions between filled C—H σ and empty C—H σ^* orbitals.
 - All staggered conformations are identical in energy, and all eclipsed conformations are identical in energy.
 - The eclipsed conformation of ethane is an energy maximum between staggered conformations.
 - The staggered conformation of ethane is lower in energy than the eclipsed conformation.

ANS: A DIF: Difficult REF: 2.5

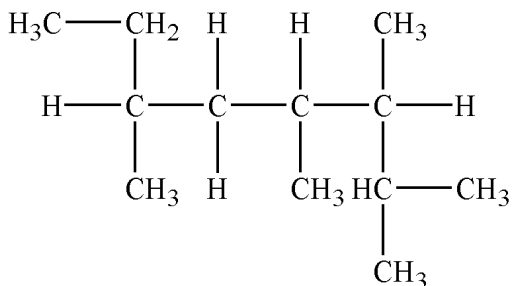
10. Which of these structures represent the *same* compound?

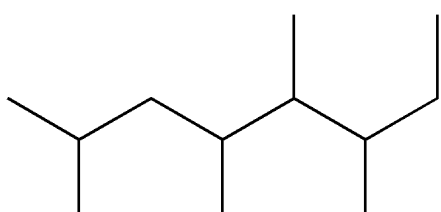
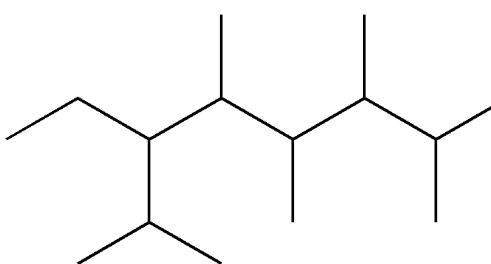


- I and II
- I and III
- II and III
- I, II, and III
- They are all different compounds.

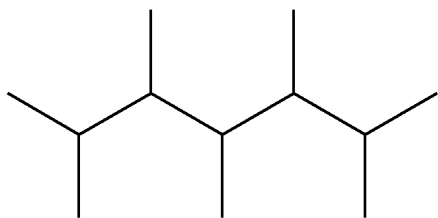
ANS: B DIF: Easy REF: 2.6

11. Which of the following line structures corresponds to the Lewis structure shown here?

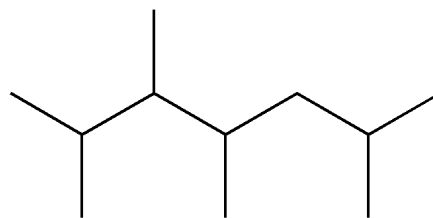


- 
- 

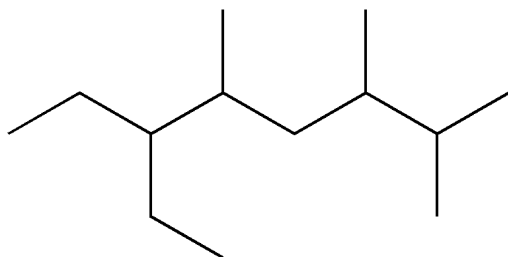
b.



e.



c.



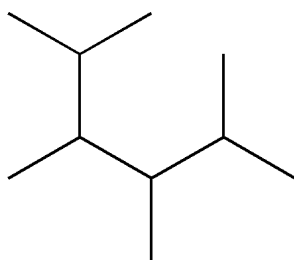
ANS: E

DIF: Medium

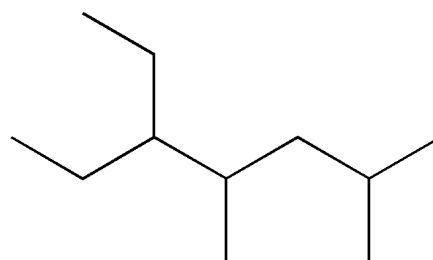
REF: 2.6

12. Which of the following compounds is *not* a structural isomer of the others?

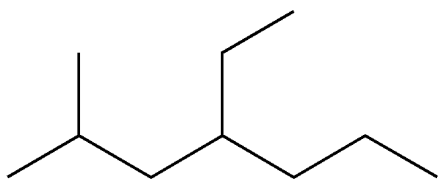
a.



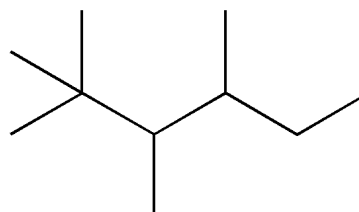
d.



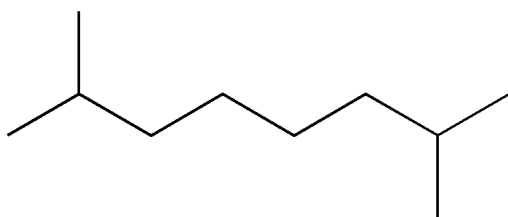
b.



e.



c.



ANS: D

DIF: Easy

REF: 2.7

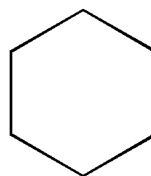
Chapter 2

13. Which of the following compounds is *not* a structural isomer of the others?

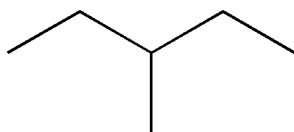
a.



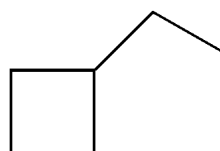
d.



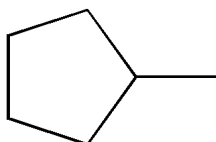
b.



e.



c.



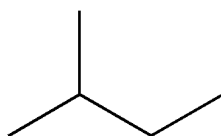
ANS: B

DIF: Easy

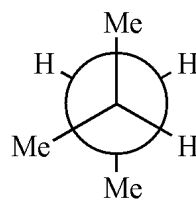
REF: 2.7

14. Which of the following structures is *not* a representation of 2-methylbutane?

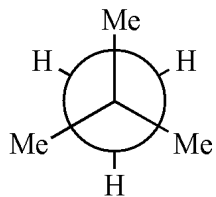
a.



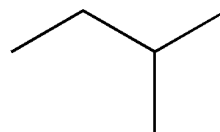
d.



b.



e.



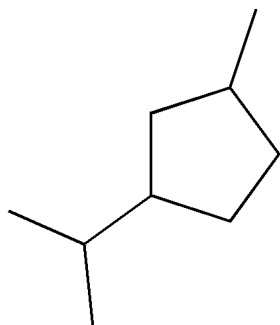
c. $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$

ANS: B

DIF: Medium

REF: 2.7

15. Which of the following choices lists the correct number of each type of carbon atom in the structure shown?



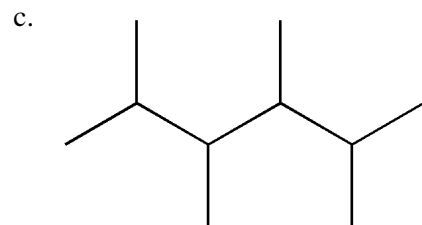
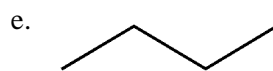
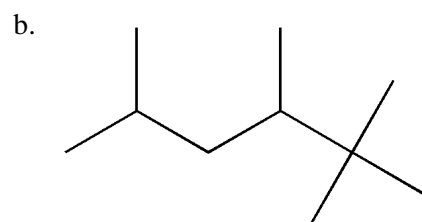
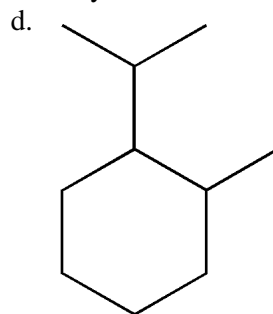
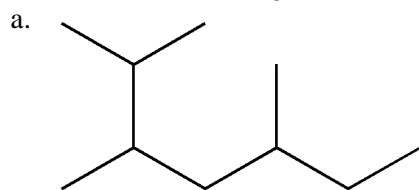
- a. 3 primary, 3 secondary, 3 tertiary
 b. 3 primary, 4 secondary, 2 tertiary
 c. 3 primary, 5 secondary, 1 tertiary
 d. 5 primary, 1 secondary, 3 tertiary
 e. 6 primary, 3 secondary, 0 tertiary

ANS: A

DIF: Easy

REF: 2.8

16. Which of the following molecules contains a quaternary carbon?



ANS: B

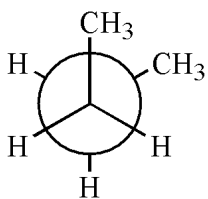
DIF: Easy

REF: 2.8

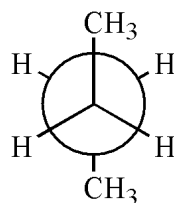
Chapter 2

17. Which of the following Newman projections shows the *highest* energy conformation of butane?

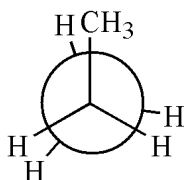
a.



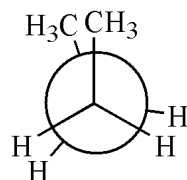
d.



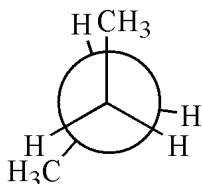
b.



e.



c.

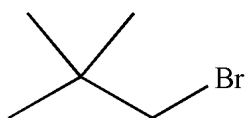


ANS: E

DIF: Medium

REF: 2.8

18. What is the systematic name of this compound?



a. 1-bromobutane

d. 1-bromo-2,2-dimethylpropane

b. 1-bromo-2-methylbutane

e. 3-bromo-2,2-dimethylpropane

c. 1-bromo-2-methylpropane

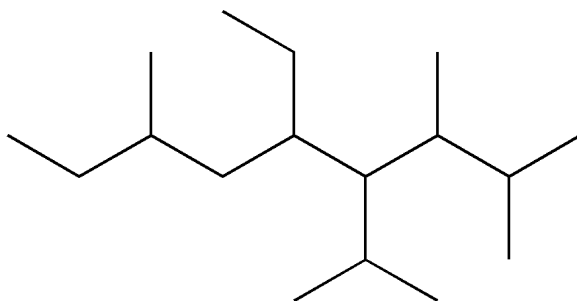
ANS: D

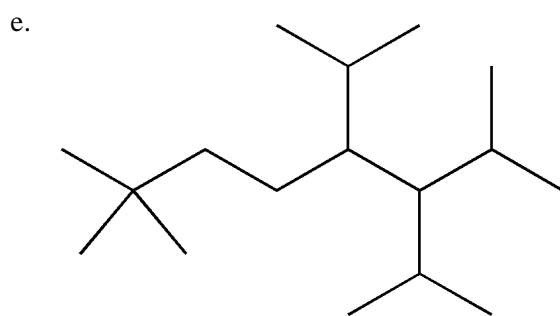
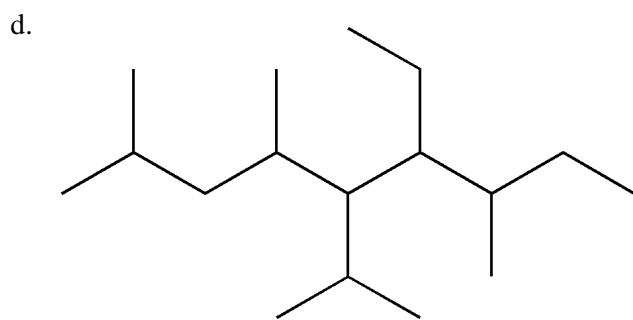
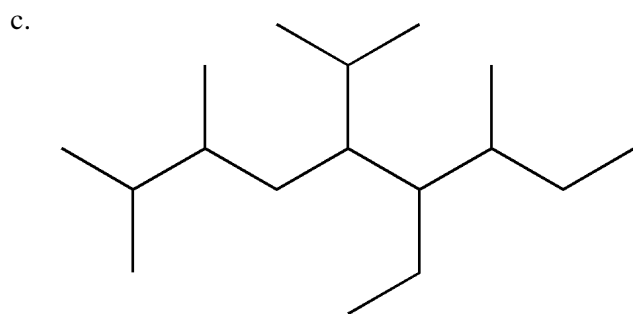
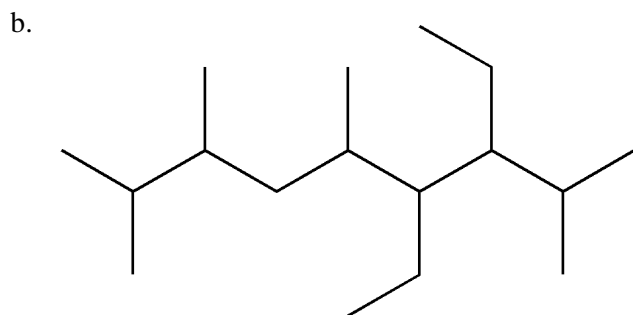
DIF: Easy

REF: 2.10

19. Which of the following structures is a correct representation of 6-ethyl-5-isopropyl-2,4,7-trimethylnonane?

a.





ANS: D DIF: Medium REF: 2.10

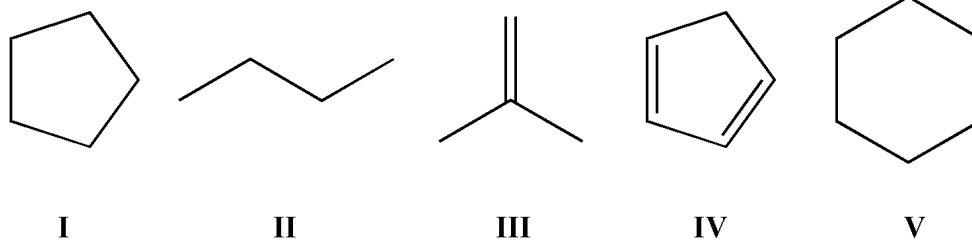
20. In which of the following molecules can a methyl group be eclipsed either by a chlorine atom or by a bromine atom?

- | | |
|----------------------------|----------------------------|
| a. 1-bromo-3-chloropropane | d. 1-chloro-2-bromopropane |
| b. 1-bromo-1-chloropropane | e. 2-bromo-2-chloropropane |
| c. 1-bromo-2-chloropropane | |

ANS: B DIF: Medium REF: 2.10

Chapter 2

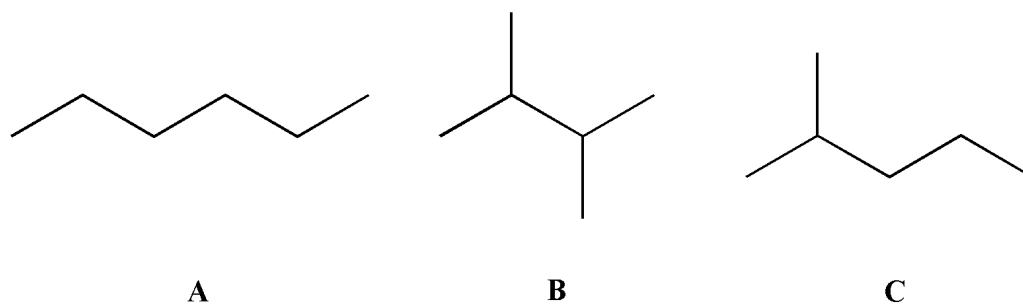
21. Which of the following structures are saturated hydrocarbons?



- a. I and V
- b. I, II, and V
- c. I, IV, and V
- d. III and IV
- e. All the structures are saturated hydrocarbons.

ANS: B DIF: Easy REF: 2.12

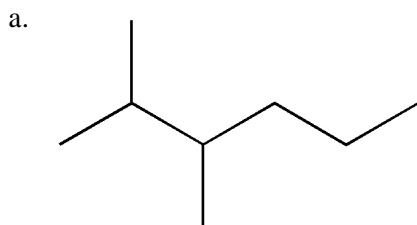
22. Which of the following statements is *true* concerning the three molecules shown?

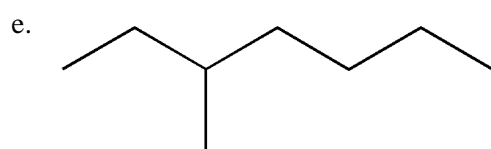
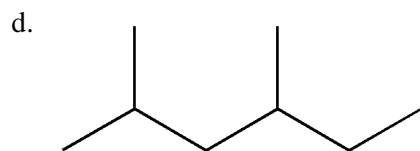
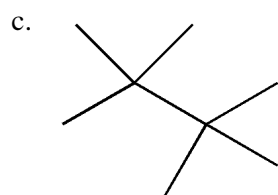
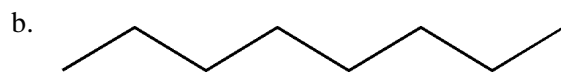


- I. The three molecules are structural isomers.
 - II. Structure C is properly named as a hexane.
 - III. Structure B has the highest boiling point of the three molecules.
 - IV. Structure A has the greatest induced dipole interactions of the three molecules.
- a. I and II
 - b. I, II, and III
 - c. I and III
 - d. I and IV
 - e. I only

ANS: D DIF: Easy REF: 2.13

23. Which of the following molecules will have the lowest boiling point?



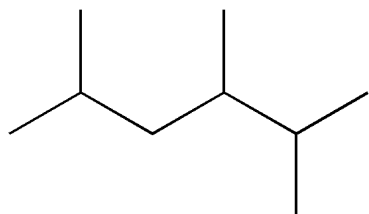


ANS: C

DIF: Easy

REF: 2.13

24. How many ^{13}C signals will appear in an NMR spectrum of the molecule shown?



a. 4

b. 5

c. 6

d. 7

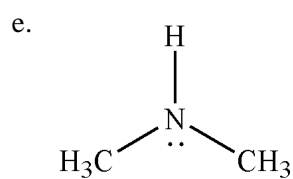
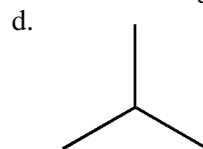
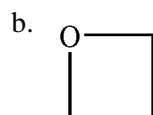
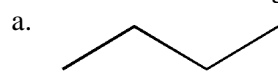
e. 9

ANS: D

DIF: Medium

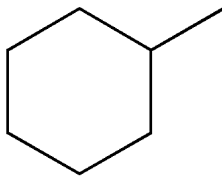
REF: 2.14

25. Which of the following structures would show more than two signals on a ^1H NMR spectrum?



Chapter 2

c.



ANS: C DIF: Medium REF: 2.14

26. Which of the following statements about chloropropanes is *false*?
- There are two signals in the ^{13}C NMR spectrum for 2-chloropropane.
 - There are two signals in the ^1H NMR spectrum for 2-chloropropane.
 - 2-Chloropropane has one structural isomer.
 - Looking down the C1—C2 bond, all eclipsed conformations of 1-chloropropane are equal in energy.
 - Looking down the C1—C2 bond, all eclipsed conformations of 2-chloropropane are equal in energy.

ANS: D DIF: Difficult REF: 2.14

SHORT ANSWER

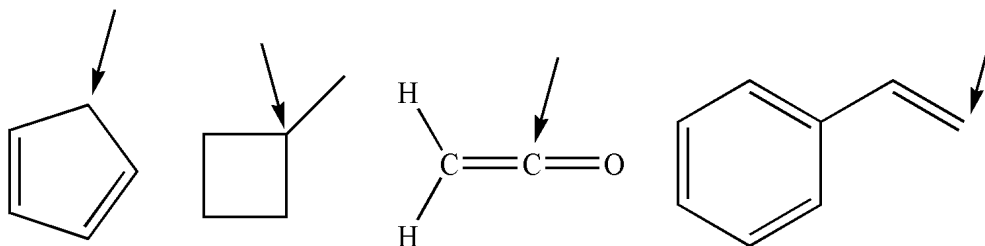
1. Describe the bonding scheme in the methyl cation $^+\text{CH}_3$. Indicate which orbitals are involved in the bonding, the hybridization of carbon, the geometry of the cation, and the H—C—H bond angles.

ANS:

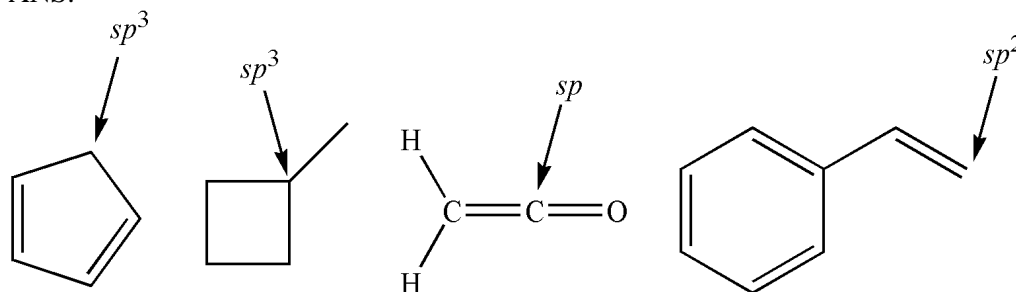
The carbon atom in methyl cation is sp^2 hybridized. Each carbon–hydrogen bond is formed by the overlap of one sp^2 hybrid orbital on carbon and one $1s$ orbital on hydrogen. The carbon atom also has an empty unhybridized $2p$ orbital. The geometry of the cation is trigonal planar and each H—C—H bond angle is 120° .

DIF: Easy REF: 2.2

2. What is the approximate hybridization of each of the indicated carbon atoms in the structures shown here?



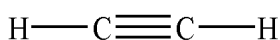
ANS:



DIF: Easy

REF: 2.2

3. What orbitals are involved from carbon and hydrogen to form each of the C—H bonds in acetylene?



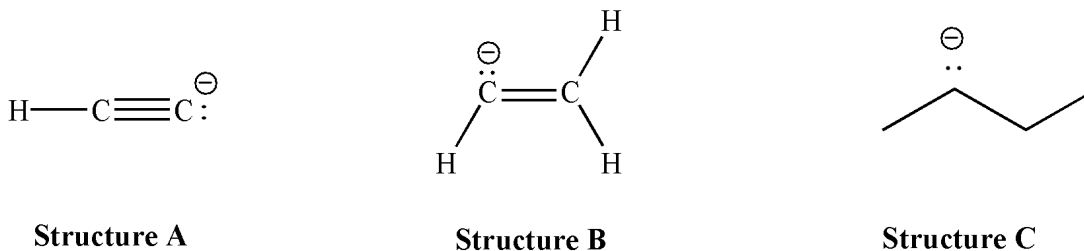
ANS:

Each C—H bond in acetylene is formed by the overlap of an sp hybrid orbital on carbon and a $1s$ orbital on hydrogen.

DIF: Easy

REF: 2.2

4. Consider the following set of carbanions:



Structure A

Structure B

Structure C

Of the three lone pairs shown, which is most stable (lowest in energy) and why?

ANS:

We must first consider the type of orbital each lone pair occupies. Because for an s orbital there is a greater probability of finding an electron closer to the nucleus than there is for a p orbital, electrons occupying orbitals with more s character are more stabilized by the electrostatic attraction to the positively charged nucleus. In structure **A**, the lone pair occupies an sp orbital (50% s , 50% p); in structure **B**, the lone pair occupies an sp^2 orbital (33.3% s , 66.7% p); and in structure **C** the lone pair occupies an sp^3 orbital (25% s , 75% p). The sp orbital has the greatest degree of s character and thus the lone pair in the sp orbital is most stable.

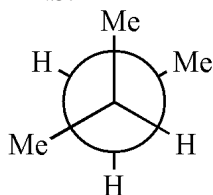
DIF: Difficult

REF: 2.2

Chapter 2

5. Draw a Newman projection looking down the C2—C3 bond for the lowest energy conformation of 2-methylbutane.

ANS:



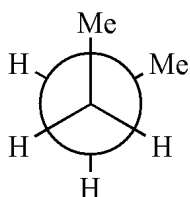
DIF: Easy

REF: 2.5

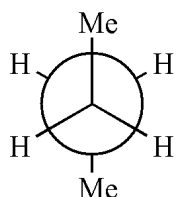
6. Draw Newman projections of all the staggered conformations of butane looking down the C2—C3 bond, and state which of them is the lowest in energy.

ANS:

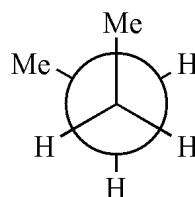
Butane has three staggered conformations: two gauche and one anti. The anti conformation is the lowest in energy.



gauche



anti

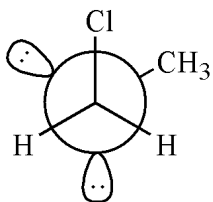


gauche

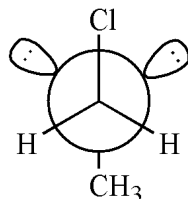
DIF: Easy

REF: 2.8

7. For compounds like $\text{CH}_3\text{OCH}_2\text{Cl}$, it has been determined that the gauche conformation shown here is lower in energy than the anti conformation, a phenomenon called the *anomeric effect*. One explanation for the anomeric effect is like the one provided for the lower energy of the staggered conformation of ethane relative to eclipsed ethane. This explanation invokes a stabilizing interaction between an empty orbital and a filled orbital in the gauche conformation of the molecule. The Newman projections shown here look down the central C—O bond:



gauche conformation
lower in energy



anti conformation
higher in energy

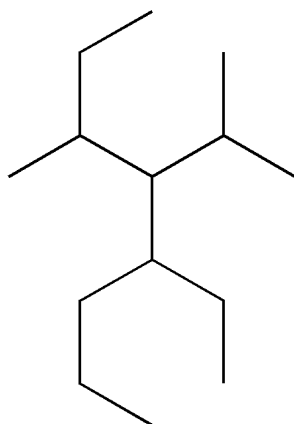
One of the orbitals involved in this theory contains one of the oxygen lone pairs. What is the other orbital?

ANS:

The other orbital is the empty C—Cl σ^* orbital.

DIF: Difficult REF: 2.8

8. Write a systematic name for the following compound.

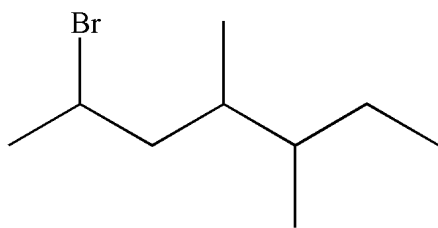


ANS:

5-Ethyl-4-isopropyl-3-methyloctane

DIF: Easy REF: 2.10

9. Write a systematic name for the following compound.



ANS:

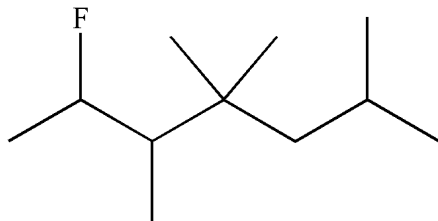
2-Bromo-4,5-dimethylheptane

DIF: Easy REF: 2.10

Chapter 2

10. Draw a structure corresponding to the systematic name 2-Fluoro-3,4,4,6-tetramethylheptane.

ANS:

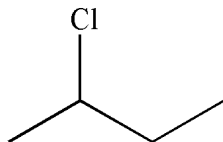


DIF: Easy

REF: 2.10

11. Draw a line structure and provide the systematic name for *sec*-butyl chloride.

ANS:



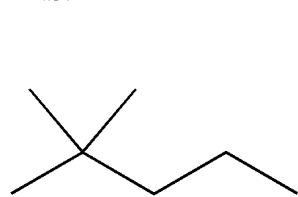
2-chlorobutane

DIF: Easy

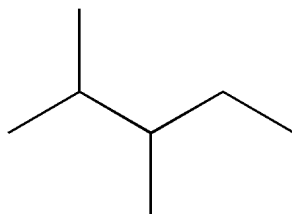
REF: 2.10

12. Draw and provide systematic names for all the structural isomers of C_7H_{16} that can be named as pentanes.

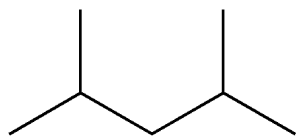
ANS:



2,2-Dimethylpentane



2,3-Dimethylpentane



2,4-Dimethylpentane



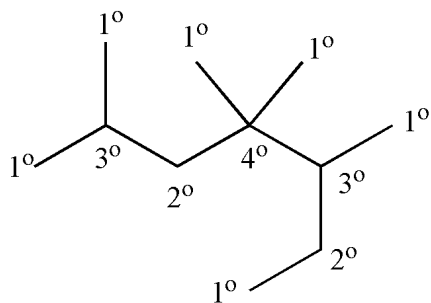
3,3-Dimethylpentane

DIF: Easy

REF: 2.10

13. Provide a line structure for 2,4,4,5-tetramethylheptane. In the structure, identify all primary (1°), secondary (2°), tertiary (3°), and quaternary (4°) carbons.

ANS:

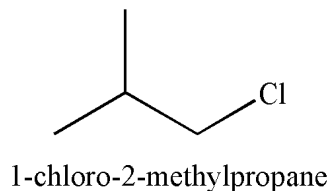
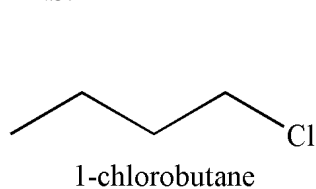


2,4,4,5-Tetramethylheptane

DIF: Medium REF: 2.10

14. Draw and provide systematic names for all the structural isomers of C_4H_9Cl where the chlorine atom is attached to a primary carbon.

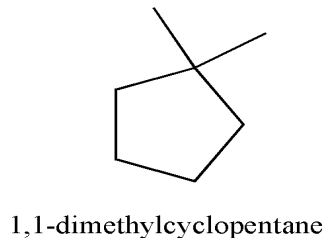
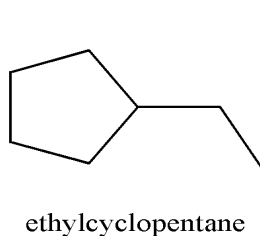
ANS:



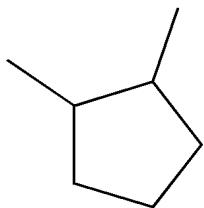
DIF: Medium REF: 2.10

15. Draw all structural isomers of C_7H_{14} that can be named as cyclopentanes, cyclohexanes, or cycloheptanes. Indicate which of these compounds can exist in cis or trans forms.

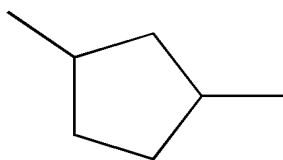
ANS:



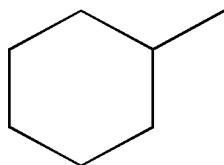
Chapter 2



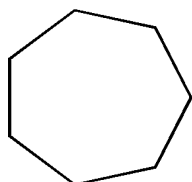
1,2-dimethylcyclopentane
(cis and trans)



1,3-dimethylcyclopentane
(cis and trans)



methylcyclohexane

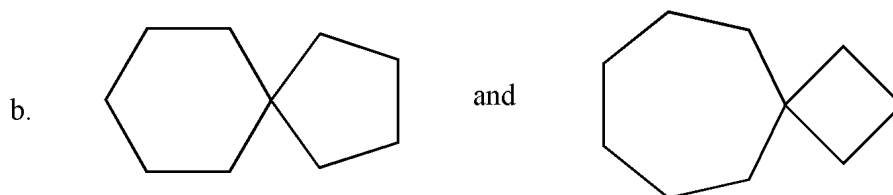
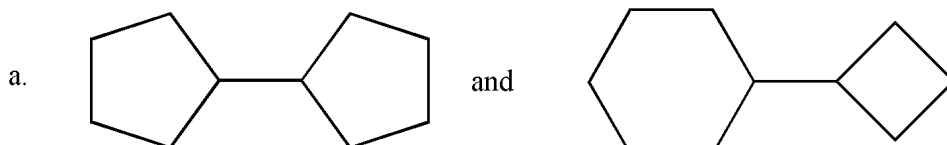


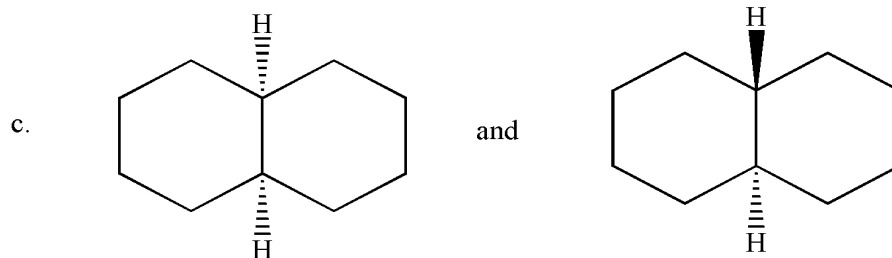
cycloheptane

DIF: Medium REF: 2.12

16. Based on the molecular formula $C_{10}H_{18}$ and using only four-, five-, six-, or seven-membered ring subunits, provide line drawings for
- two different compounds where two rings do not share any carbons.
 - two different compounds where two rings share one carbon.
 - two different compounds where two rings share two carbons.

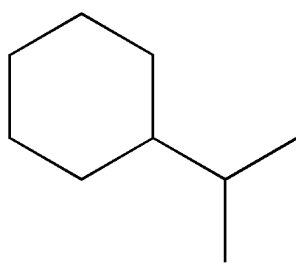
ANS:





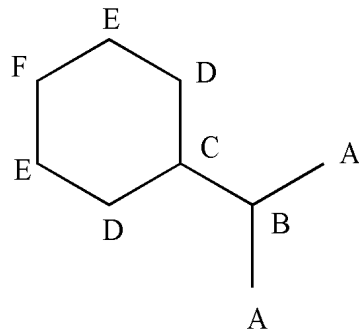
DIF: Medium REF: 2.12

17. How many signals will be seen in the ^1H NMR spectrum for the following molecule? What will be the relative sizes of these signals?



ANS:

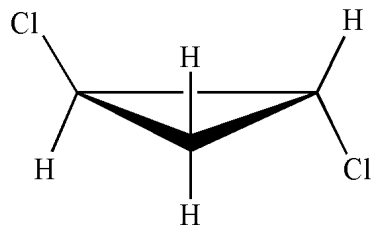
There will be six signals in the ^1H NMR spectrum. Relative sizes are indicated on the structure below:



Signal A - 6 hydrogens, relative size = 6
 Signal B - 1 hydrogen, relative size = 1
 Signal C - 1 hydrogen, relative size = 1
 Signal D - 4 hydrogens, relative size = 4
 Signal E - 4 hydrogens, relative size = 4
 Signal F - 2 hydrogens, relative size = 2

DIF: Medium REF: 2.14

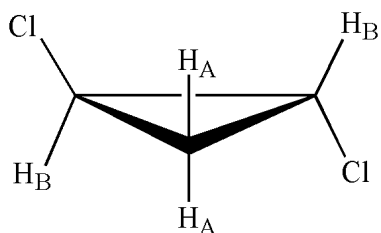
18. How many signals will appear in the ^1H NMR spectrum for the molecule shown here? Identify the hydrogen atoms that will generate each signal by labeling them as H_A , H_B , and so on.



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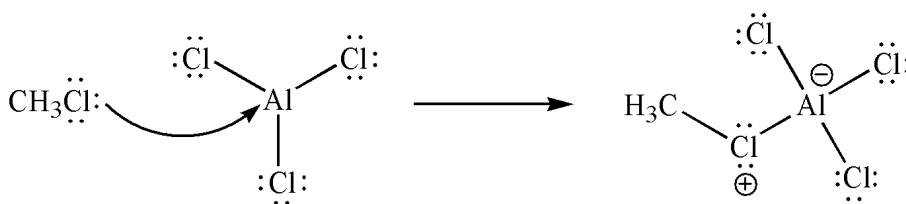
ANS:

There will be two signals in the ^1H NMR spectrum.

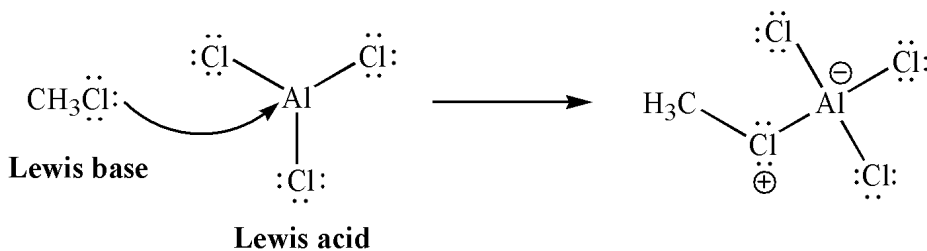


DIF: Difficult REF: 2.14

19. The reaction shown here is one you will encounter later in this course. Identify the Lewis base and the Lewis acid.

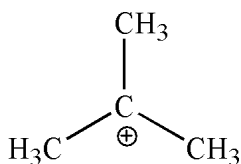


ANS:



DIF: Easy REF: 2.15

20. *Tertiary*-Butyl cation is an example of a carbocation.



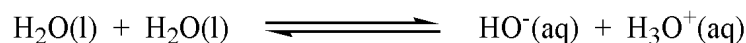
State whether a carbocation is a Lewis acid or a Lewis base, and explain your reasoning.

ANS:

A carbocation is a Lewis acid. The carbon bearing the positive charge is sp^2 hybridized and has an unoccupied $2p$ orbital that can interact with a filled orbital in a Lewis base.

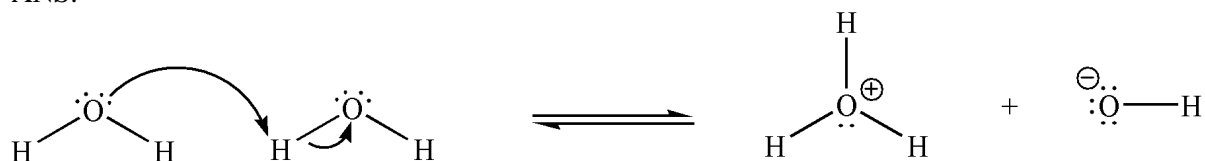
DIF: Medium REF: 2.15

21. Pure water at 25° C undergoes *autoionization*:



Using curved arrow formalism, draw a mechanism for the transfer of a proton from one water molecule to another to form hydroxide ion and hydronium ion. Show all lone pairs of electrons and non-zero formal charges.

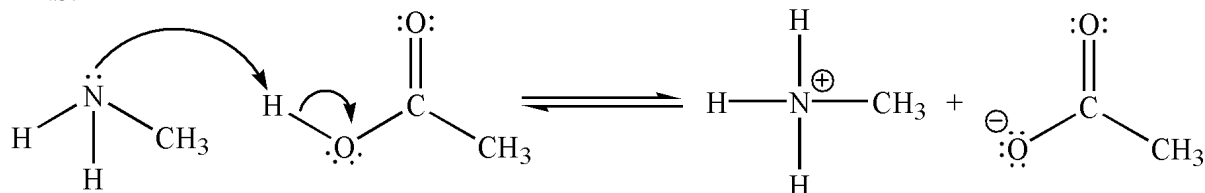
ANS:



DIF: Medium REF: 2.15

22. Using curved arrow formalism, draw a mechanism for the transfer of a proton from acetic acid, CH_3COOH , to methylamine, CH_3NH_2 . Draw the products of the reaction and show all lone pairs of electrons and nonzero formal charges.

ANS:



DIF: Medium REF: 2.15

23. True or false:

All Lewis bases may act as Brønsted bases, but not all Lewis acids may act as Brønsted acids.

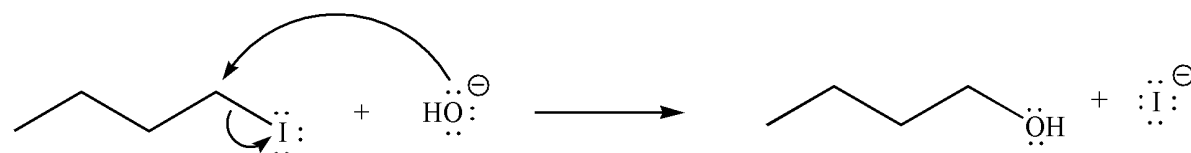
Explain your answer, providing any examples necessary to support your explanation.

ANS:

True. Lewis bases are electron-pair donors and Brønsted bases are proton acceptors. To accept a proton, a chemical species must have a lone pair; thus, all Lewis bases may act as Brønsted bases since they can accept a proton. However, not all Lewis acids may act as Brønsted acids. The definition of a Brønsted acid is a proton donor, and there are numerous examples of Lewis acids, such as BF_3 , that do not donate protons.

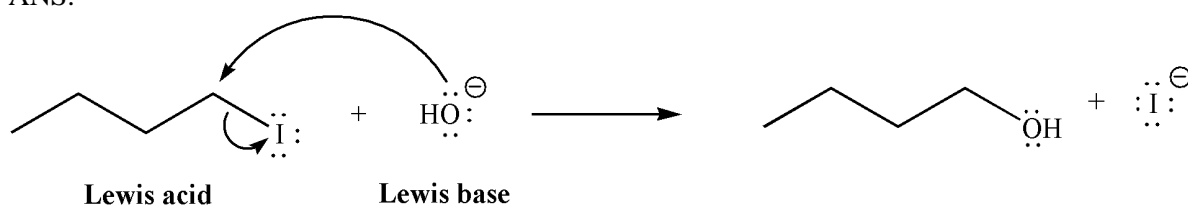
DIF: Medium REF: 2.15

24. The reaction shown here is one you will encounter later in this course. Identify the Lewis base and the Lewis acid in the reaction.



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ANS:



DIF: Difficult REF: 2.15