*Essential Organic Chemistry*, 2e (Bruice)

## Chapter 3 An Introduction to Organic Compounds: Nomenclature, Physical Properties, and Representation of Structure

1) Explain what is meant by the term "saturated hydrocarbons."
Answer: These are compounds containing only single bonded carbons and hydrogens where each carbon has the maximum number of hydrogens bonded to it. The alkanes are saturated hydrocarbons.
*Section: 3.0*

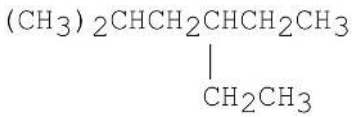
2) Describe the carbon-carbon bond differences between alkanes, alkene, and alkynes.
Answer: Alkanes contain only carbon-carbon single bonds. Alkenes contain at least one carbon-carbon double bond. Alkynes contain at least one carbon-carbon triple bond.
*Section: 3.0*

3) Explain the relationship between alkanes and gasoline.
Answer: Petroleum is a complex mixture of alkanes and cycloalkanes that are separated into different fractions by distillation. 5 to 11-carbon alkanes are used for gasoline. Straight-chain alkanes are poor fuels so catalytic cracking is used to convert these straight-chain alkanes into branched-chain alkanes which are high-performance fuels.
*Section: 3.0*

4) Explain why alkanes are generally considered unreactive compounds.
Answer: They are unreactive because they have only strong σ bonds and atoms which have no partial charges.
*Section: 3.0*

5) Which of the following is the best description of propane, $CH_3CH_2CH_3$, at room temperature?
A) liquid, soluble in $H_2O$
B) gas, soluble in gasoline
C) liquid, soluble in gasoline
D) gas, soluble in water
E) solid, soluble in gasoline
Answer: B
*Section: 3.1*

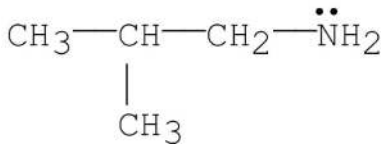
6) The following molecule contains how many 1°, 2°, and 3° hydrogens?



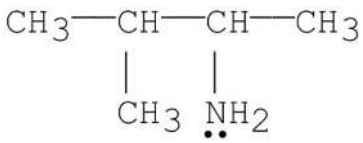
Answer: 12 =1°, 6 =2°, 2 =3°
*Section: 3.1*

7) Which of the following is a tertiary amine?

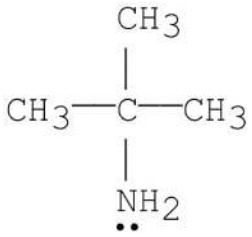
A)



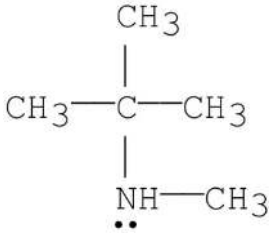
B)



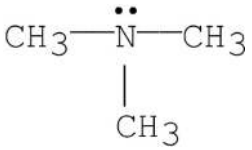
C)



D)



E)



Answer: E

*Section: 3.1 and 3.5*

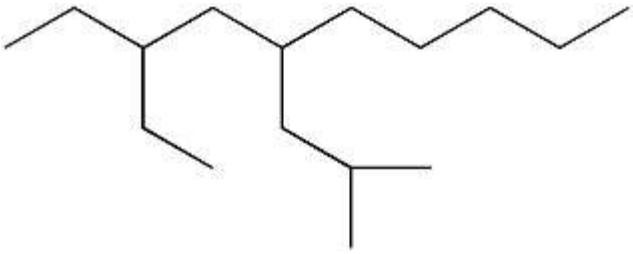
8) There are 8 isomers that have the molecular formula $C_5H_{11}Br$. How many of these are tertiary alkyl bromides?

A) 0
B) 1
C) 2
D) 3
E) 8

Answer: B

*Section: 3.1*

9) Draw the structure for 3-ethyl-5-isobutyldecane.
Answer:



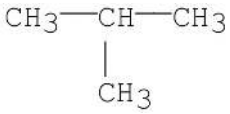
*Section: 3.1*

10) Which of the following is *sec*-butyl alcohol?
A) $CH_3CH_2CH_2CH_2OH$
B) $CH_3CH(OH)CH_2CH_3$
C) $(CH_3)_2CHCH_2OH$
D) $(CH_3)_2CHOH$
E) $(CH_3)_2CHOCH_3$
Answer: B
*Section: 3.1*

11) How should $(CH_3)_2C(OH)CH_2CH_3$ be classified?
A) primary alcohol
B) secondary alcohol
C) tertiary alcohol
D) quarternary alcohol
E) none of the above
Answer: C
*Section: 3.1 and 3.5*

12) How should $CH_3CHClCH_2CH_3$ be classified?
A) primary alkyl halide
B) secondary alkyl halide
C) tertiary alkyl halide
D) quarternary alkyl halide
E) pentanary alkyl halide
Answer: B
*Section: 3.1 and 3.5*

13) What is the common name for the following structure?

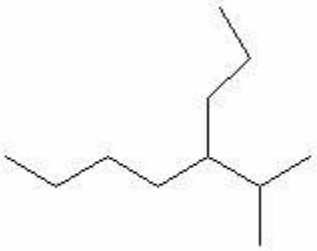


A) Isobutane
B) Isopropylmethane
C) *t*-Butane
D) *n*-Butane
E) *sec*-Butane

Answer: A

*Section: 3.2*

14) Give the IUPAC name for the following structure:



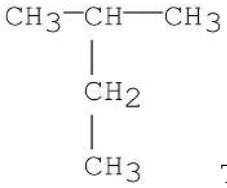
A) 2-methyl-3-ethylheptane
B) 3-ethyl-2-methylheptane
C) 5-Isopropyloctane
D) 4-Isopropyloctane
E) 2-methyl-3-propylheptane

Answer: D

*Section: 3.2*

15) There is something wrong with the following name. Write the structure and correct the name: 2-ethylpropane.

Answer:

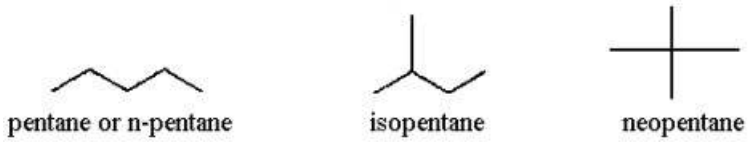


The correct name is 2-methylbutane.

*Section: 3.2*

16) Give structures for the three isomers with molecular formula $C_5H_{12}$ and provide the common name of each.

Answer:




*Section: 3.2*

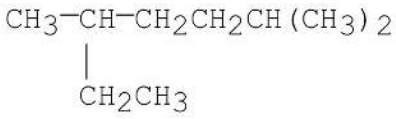
17) Provide an acceptable name for the alkane shown below.

$CH_3CH_2CH_2CH_2CH_2CH_3$

Answer: hexane or *n*-hexane

*Section: 3.2*

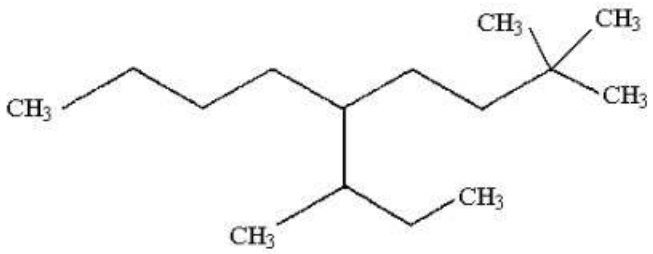
18) Provide an acceptable name for the alkane shown below.



Answer: 2,5-dimethylheptane

*Section: 3.2*

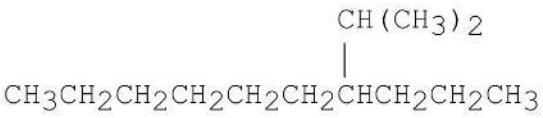
19) Provide an acceptable name for the alkane shown below.



Answer: 5-*sec*-butyl-2,2-dimethylnonane or
2,2-dimethyl-5-(1-methylpropyl) nonane

*Section: 3.2*

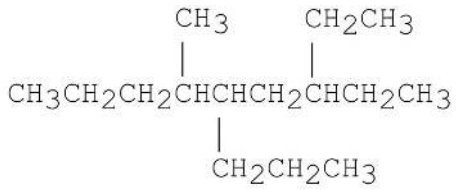
20) Provide an acceptable name for the alkane shown below.



Answer: 4-isopropyldecane or 4-(1-methlyethyl) decane

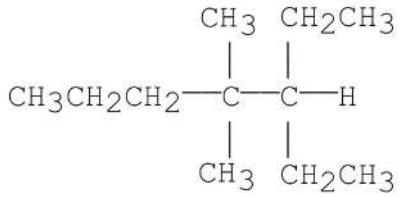
*Section: 3.2*

21) Provide an acceptable name for the alkane shown below.



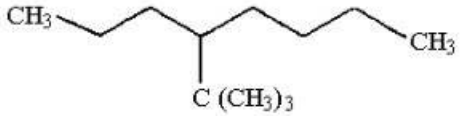
Answer: 3-ethyl-6-methyl-5-propylnonane
*Section: 3.2*

22) Provide an acceptable name for the alkane shown below.



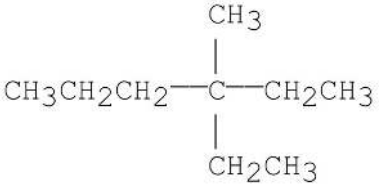
Answer: 3-Ethyl-4, 4-dimethylheptane
*Section: 3.2*

23) Draw an acceptable structure for 4-*t*-butyloctane.
Answer:



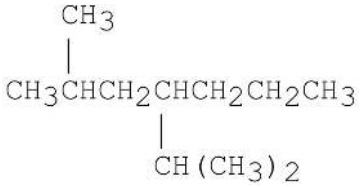
*Section: 3.2*

24) Draw an acceptable structure for 3-ethyl-3-methylhexane.
Answer:



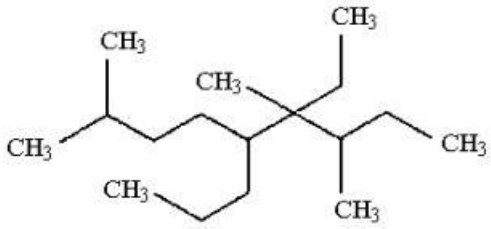
*Section: 3.2*

25) Draw an acceptable structure for 4-isopropyl-2-methylheptane.
Answer:



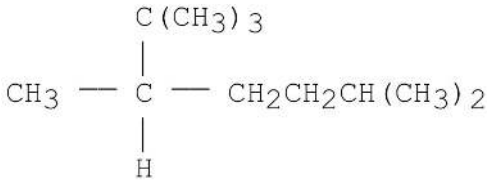
*Section: 3.2*

26) Draw an acceptable structure for 6-ethyl-2,6,7-trimethyl-5-propylnonane.
Answer:



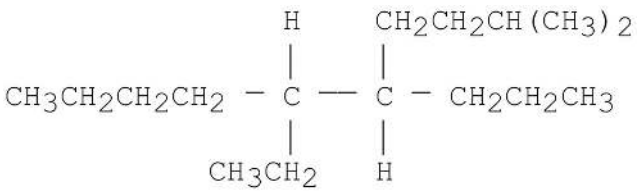

*Section: 3.2*

27) Provide an acceptable name for the alkane shown below.



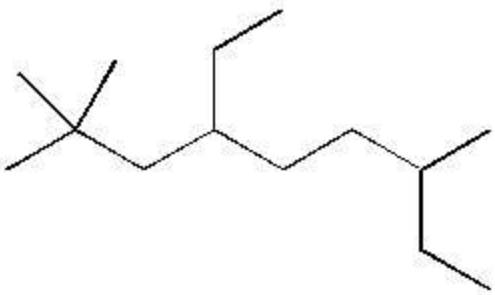

Answer: 2,2,3,6-tetramethylheptane
*Section: 3.2*

28) Provide an acceptable name for the alkane shown below.



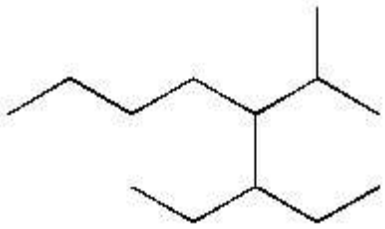

Answer: 6-ethyl-2-methyl-5-propyldecane
*Section: 3.2*

29) Give the systematic name of the alkane shown below.



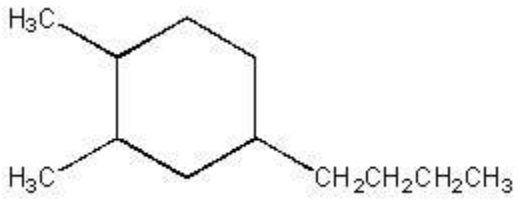
Answer: 4-ethyl-2,2,7-trimethylnonane
*Section: 3.2*

30) Give the systematic name of the alkane shown below.



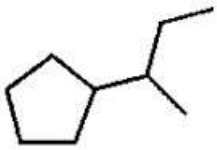
Answer: 3-ethyl-4-isopropyloctane
*Section: 3.2*

31) Give the systematic name of the cycloalkane shown below.



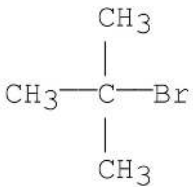

Answer: 4-butyl-1,2-dimethylcyclohexane
*Section: 3.3*

32) Draw an acceptable structure for sec-butylcyclopentane.
Answer:



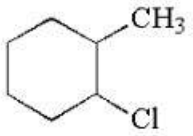
*Section: 3.3*

33) What is the common name for the following structure?




A) Isobutyl bromide
B) *t*-Butyl bromide
C) Neobutyl bromide
D) *sec*-Butyl bromide
E) Isopropyl methyl bromide
Answer: B
*Section: 3.4*

34) Give the IUPAC name for the following compound:



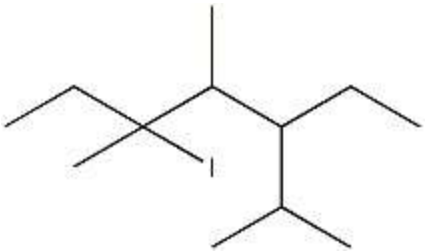

A) 1-chloro-2-methylcyclohexane
B) 1-methyl-2-chlorocyclohexane
C) 1-chloro-5-methylcyclohexane
D) 1-methyl-5-chlorocyclohexane
E) 1,2-chloromethylcyclohexane

Answer: A

*Section: 3.4*

35) Draw the structure for 3-iodo-5-isopropyl-3,4-dimethylheptane

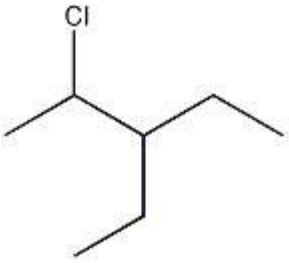
Answer:




*Section: 3.4*

36) Draw the structure for 2-chloro-3-ethylpentane

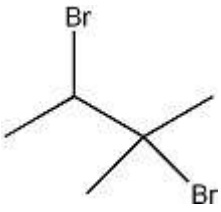
Answer:




*Section: 3.4*

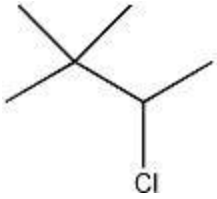
37) Draw the structure of 2,3-dibromo-2-methylbutane.

Answer:




*Section: 3.4*

38) How is the structure shown below classified?

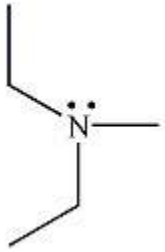



A) a primary alkyl halide
B) a primary alcohol
C) a secondary alkyl halide
D) a secondary alcohol
E) a tertiary alkyl halide

Answer: C

*Section: 3.5*

39) How is the structure shown below classified?




A) a quarternary ammonium ion
B) a quarternary amine
C) a secondary amine
D) a primary amine
E) a tertiary amine

Answer: E

*Section: 3.5*

40) How is (CH3)3CCHClCH3 classified?

A) a primary alkyl halide
B) a primary alkyl chloride
C) a secondary alkyl chloride
D) a tertiary alkyl chloride
E) a quarternary alkyl chloride

Answer: C

*Section: 3.5*

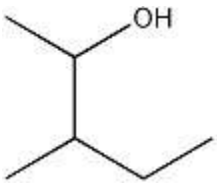
41) How is $NH_4^+Cl^-$ classified?

A) a quarternary ammonium salt
B) a primary amine
C) a secondary amine
D) a secondary ammonium salt
E) a tertiary ammonium salt

Answer: A

*Section: 3.5*

42) How is the structure shown below classified?




A) a secondary alcohol
B) a primary alcohol
C) a quarternary alcohol
D) a tertiary alcohol
E) an ether

Answer: A
*Section: 3.5*

43) What is the hybridization of the nitrogen atom in $CH_3NH_2$?

A) *sp*
B) $sp^2$
C) $sp^3$
D) *s*-$sp^3$
E) a primary amine

Answer: C
*Section: 3.6*

44) What is the hybridization of the carbon atom in $CH_3NH_2$?

A) $3sp^3$
B) sp
C) $sp^2$
D) $sp^3$
E) $d^2sp^3$

Answer: D
*Section: 3.6*

45) What is the hybridization of the oxygen atom in $CH_3CH_2OH$?

A) sp
B) $4sp^3$
C) $sp^2$
D) $d^2sp^3$
E) $sp^3$

Answer: E
*Section: 3.6*

46) Which of the following statements is correct for a saturated alkyl halide?
A) the C-X bond results from overlap of the *s* orbital of carbon and the *p* orbital of the halogen (X)
B) the C-X bond results from overlap of the *p* orbital of carbon and the *p* orbital of the halogen (X)
C) the C-X bond results from overlap of the $sp^3$ orbital of carbon and the *p* orbital of the halogen (X)
D) the C-X bond results from overlap of the $sp^2$ orbital of carbon and the *p* orbital of the halogen (X)
E) the C-X bond results from overlap of the *sp* orbital of carbon and the *p* orbital of the halogen (X)
Answer: C
*Section: 3.6*

47) Where are the two lone pairs of electrons of the oxygen atom in an alcohol molecule located?
A) in two *s* orbitals
B) in two *p* orbitals
C) in two *sp* orbitals
D) in two $sp^2$ orbitals
E) in two $sp^3$ orbitals
Answer: E
*Section: 3.6*

48) Fluorine is more electronegative than chlorine yet the carbon-fluorine bond in $CH_3$-F is shorter than $CH_3$-Cl. Explain.
Answer: Chlorine is a larger atom than fluorine and uses a 3*p* rather than 2*p* orbital. The overlap of a carbon $2sp^3$ orbital with a chlorine 3*p* orbital is not as good as the overlap of a carbon $2sp^3$ orbital with a fluorine 2*p* orbital, causing the bond to be longer and weaker.
*Section: 3.6*

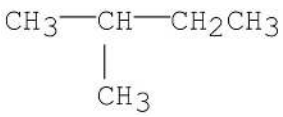
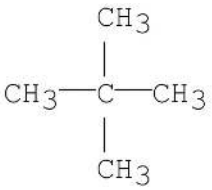
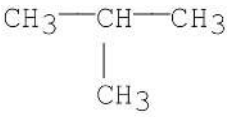
49) Explain why $CH_3CH_2CH_2CH_2OH$ (74g/mol) has a boiling point of 117.3°C while $CH_3CH_2CH_2CH_2CH_3$ (72g/mol) has a boiling point of 36.1°C.
Answer: The alcohol has to overcome van der Waals forces, dipole-dipole interactions, and hydrogen bonding in order to reach the boiling point while the alkane of similar molar mass (molecular weight) only has van der Waals forces to overcome which are the weakest form of intermolecular interactions.
*Section: 3.7*

50) What type of intermolecular interactions does $(CH_3CH_2)_2NH$ undergo?
A) induced dipole-induced dipole
B) dipole-dipole
C) hydrogen bonding
D) A and B
E) A, B, and C
Answer: E
*Section: 3.7*

51) Which of the following is the strongest interaction?
A) a covalent bond
B) induced dipole-induced dipole interactions
C) dipole-dipole interactions
D) hydrogen bonding
E) van der Waals
Answer: A
*Section: 3.7*

52) Rank the following molecules in increasing order of solubility in water: $HOCH_2CH_2OH$, $CH_3CH_2OH$, $CH_3CH_2CH_3$
Answer: $CH_3CH_2CH_3 < CH_3CH_2OH < HOCH_2CH_2OH$
*Section: 3.7*

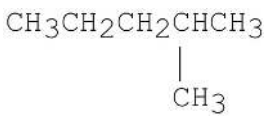
53) Which of the following will have the lowest boiling point?
A) $CH_3Cl$
B) $CH_4$
C) $CH_2Cl_2$
D) $CHCl_3$
E) $CCl_4$
Answer: B
*Section: 3.7*

54) Which of the following has the greatest van der Waal's interaction between molecules of the same kind?
A)

B) $CH_3CH_2CH_2CH_3$
C)

D) $CH_3CH_2CH_2CH_2CH_3$
E)

Answer: D
*Section: 3.7*

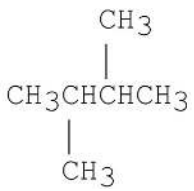
55) Which of the following has the lowest boiling point?

A) $CH_3CH_2CH_2CH_2CH_2CH_3$

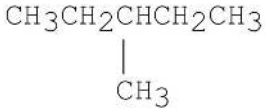
B)



C)



D)



E) $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

Answer: C

*Section: 3.7*

56) Which of the following has the greatest solubility in $CH_3CH_2CH_2CH_3$?

A) $CH_3OH$

B) $CH_3O^-Na^+$

C) $CH_3NH_2$

D) $CH_3OCH_3$

E) $(CH_3)_3CH$

Answer: E

*Section: 3.7*

57) Which of the following is the most soluble in $H_2O$?

A) $CH_3OCH_3$

B) $CH_3CH_2OH$

C) $CH_3CH_2Cl$

D) $CH_3CH_2CH_3$

E) $CH_3CHO$

Answer: B

*Section: 3.7*

58) Which of the following would have the highest boiling point?

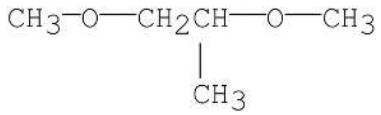
A) $CH_3CH_2OCH_2CH_2OCH_3$

B) $CH_3OCH_2CH_2CH_2OCH_3$

C) $HOCH_2CH_2CH_2CH_2OH$

D) $CH_3CH_2OCH_2OCH_2CH_3$

E)



Answer: C

*Section: 3.7*

59)

Explain why $CH_3CHCH_3$ (with $CH_3$ branch) has a lower boiling point than $CH_3CH_2CH_2CH_3$.

Answer: $CH_3CH_2CH_2CH_3$ has greater dispersion forces because it has an extended structure and has a greater contact area than isobutane. Therefore, the boiling point of $CH_3CH_2CH_2CH_3$ is higher.

*Section: 3.7*

60) Primary and secondary amines exhibit hydrogen bonding; tertiary amines do not. Explain.

Answer: The nitrogen in a tertiary amine is not attached to a hydrogen. Recall that for a molecule to exhibit hydrogen bonding, it must have a hydrogen attached to a highly electronegative atom such as F, N, or O.

*Section: 3.7*

61) Explain why trimethylamine, $(CH_3)_3N$:, has a considerably lower boiling point than propylamine $CH_3CH_2CH_2NH_2$, even though both compounds have the same molecular formula.

Answer: Since hydrogen bonding is possible for propylamine and not for trimethylamine, the boiling point is higher for propylamine.

*Section: 3.7*

62) Which of the molecules below has the higher boiling point? Briefly explain your choice.

$CH_3CH_2CH_2OH$ or $CH_3CH_2OCH_3$

Answer: $CH_3CH_2CH_2OH$ has the higher boiling point since it is capable of intermolecular hydrogen bonding.

*Section: 3.7*

63) Would you expect sodium chloride (NaCl) to be highly soluble in the organic solvent hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)? Briefly explain your answer.

Answer: One would <u>not</u> expect NaCl to be highly soluble in hexane. NaCl is an ionic solid (i.e., a very polar material) while hexane is nonpolar. Nonpolar solvent molecules do not solvate ions well. The attractions of oppositely charged ions to each other are vastly greater than the extremely weak attractions of the ions for the solvent.

*Section: 3.7*

64) Which compound is more soluble in water? Briefly explain your choice.

$CH_3OCH_3$ or $CH_3CH_2OH$

Answer: $CH_3CH_2OH$ is more soluble in water since it can donate a hydrogen bond to water and accept a hydrogen bond from water. $CH_3OCH_3$ can only accept a hydrogen bond from water; it has no acidic hydrogen which can hydrogen bond to water.

*Section: 3.7*

65) Which compound is more soluble in water? Briefly explain your choice.

$(CH_3)_2NH$ or $CH_3CH_2CH_3$

Answer: $(CH_3)_2NH$ is more soluble in water since it can hydrogen bond with water. Alkanes are not capable of hydrogen bonding with water.

*Section: 3.7*

66) Which intermolecular force is primarily responsible for the interactions among alkane molecules?

Answer: Van der Waal's or London forces

*Section: 3.7*

67) Consider the three isomeric alkanes n-hexane, 2, 3-dimethylbutane, and 2-methylpentane. Which of the following correctly lists these compounds in order of increasing boiling point?

A) 2,3-dimethylbutane < 2-methylpentane < *n*-hexane
B) 2-methylpentane < n-hexane < 2,3-dimethylbutane
C) 2-methylpentane < 2, 3-dimethylbutane < *n*-hexane
D) *n*-hexane < 2-methylpentane < 2,3-dimethylbutane
E) *n*-hexane < 2,3-dimethylbutane < 2-methylpentane

Answer: A

*Section: 3.7*

68) What is the strongest intermolecular force present in liquid ethanol?

A) induced dipole-induced dipole
B) dipole-dipole, specifically hydrogen bonding
C) dipole-dipole, but not hydrogen bonding
D) ion-dipole
E) ion-ion

Answer: B

*Section: 3.7*

69) Assuming roughly equivalent molecular weights, which of the following would have the highest boiling point?

A) a tertiary amine
B) a quaternary ammonium salt
C) an alcohol
D) an ether
E) an alkyl chloride

Answer: B

*Section: 3.7*

70) Arrange the following amines in order of increasing boiling point, lowest bp to highest bp: $(CH_3)_2CHCH_2CH_2NH_2$, $(CH_3)_2CHN(CH_3)_2$, and $(CH_3)_2CHCH_2NHCH_3$.

Answer: $(CH_3)_2CHN(CH_3)_2 < (CH_3)_2CHCH_2NHCH_3 < (CH_3)_2CHCH_2CH_2NH_2$

*Section: 3.7*

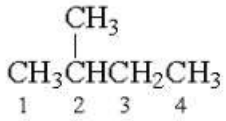
71) The eclipsed and staggered forms of ethane are said to differ in _____.

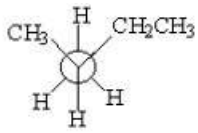
A) molecular formula
B) configuration
C) conformation
D) constitution
E) structure

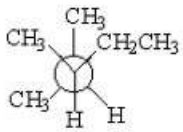
Answer: C

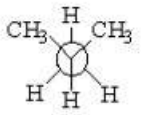
*Section: 3.8*

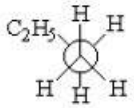
72) Which of the following is the staggered conformation for rotation about the $C_2$–$C_1$ bond in the following structure?

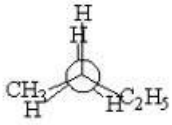


I. 

II. 

III. 

IV. 

V. 

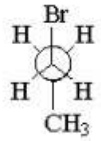
A) I
B) II
C) III
D) IV
E) V

Answer: A

*Section: 3.8*

73) Draw the Newman structure for the most stable conformation of 1-bromopropane considering rotation about the $C_1$-$C_2$ bond.

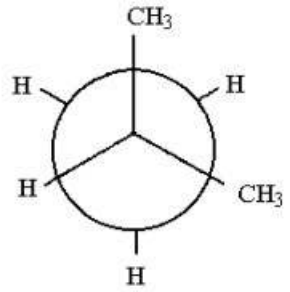
Answer:



*Section: 3.8*

74) Draw a Newman projection of the most stable conformation of 2-methylpropane as viewed along the $C_1$-$C_2$ bond axis.

Answer:




*Section: 3.8*

75) Explain why a staggered conformation has a low energy than an eclipsed conformation.

*Section: 3.8*

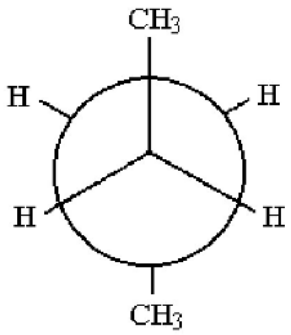
76) Define the term "conformation."

Answer: Conformations are different arrangements of the same molecule formed by rotations about single bonds.

*Section: 3.8*

77) View a butane molecule along the $C_2$-$C_3$ bond and provide a Newman projection of the lowest energy conformer.

Answer:




*Section: 3.8*

78) Which of the following best explains the relative stabilities of the eclipsed and staggered forms of ethane? The _____ form has the most _____ strain.

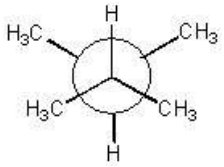
A) eclipsed; steric
B) eclipsed; torsional
C) staggered; steric
D) staggered; torsional

Answer: B

*Section: 3.8*

79) Draw the Newman projection of the most stable conformation that results due to rotation about the $C_2$-$C_3$ bond in 2,3-dimethylbutane.

Answer:




*Section: 3.8*

80) Which of the following correctly ranks the cycloalkanes in order of increasing ring strain per methylene?

A) cyclopropane < cyclobutane < cyclohexane < cycloheptane
B) cyclohexane < cyclopentane < cyclobutane < cyclopropane
C) cyclopentane < cyclobutane < cyclopentane < cyclopropane
D) cyclopentane < cyclopropane < cyclobutane < cyclohexane
E) cyclopropane < cyclopentane < cyclobutane < cyclohexane

Answer: B

*Section: 3.9*

81) Describe the source of angle strain and torsional strain present in cyclopropane.

Answer: The angle strain arises from the compression of the ideal tetrahedral bond angle of 109.5° to 60°. The large torsional strain occurs since all C-H bonds on adjacent carbons are eclipsed.

*Section: 3.9*

82) What is Latin for "across"?

A) substituent
B) cis
C) trans
D) geometric isomer

Answer: C

*Section: 3.11*

83) Which of the following describes the most stable conformation of trans-1-*tert*-butyl-3-methylcyclohexane?

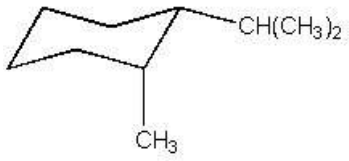
A) Both groups are equatorial.
B) Both groups are axial.
C) The *tert*-butyl group is equatorial.
D) The *tert*-butyl group is axial and the methyl group is equatorial.
E) none of the above

Answer: C

*Section: 3.12*

84) Draw the most stable conformation of *cis*-1-isopropyl-2-methylcyclohexane.

Answer:




*Section: 3.12*

85) Which of the following has two equatorial alkyl substituents in its most stable conformation?
A) 1,1-dimethylcyclohexane
B) *cis*-1,2-dimethylcyclohexane
C) *cis*-1,3-diethylcyclohexane
D) *cis*-1,4-diethylcyclohexane
E) all of the above
Answer: C
*Section: 3.12*

86) Draw the most stable conformation of *trans*-decalin.
Answer:

*Section: 3.13*