

CHAPTER 2—ALKANES AND CYCLOALKANES

MULTIPLE CHOICE

1. Approximately how long is a C–C single bond of an alkane?
 - a. 111 pm
 - b. 134 pm
 - c. 142 pm
 - d. 153 pm

ANS: D

2. What is the approximate C–C–C bond angle in propane?
 - a. 90°
 - b. 109°
 - c. 120°
 - d. 180°

ANS: B

3. What is the name of the linear hydrocarbon with the molecular formula C_7H_{16} ?
 - a. hexane
 - b. heptane
 - c. decane
 - d. undecane

ANS: B

4. What is the name of the linear hydrocarbon with the molecular formula $C_{11}H_{24}$?
 - a. heptane
 - b. decane
 - c. undecane
 - d. eicosane

ANS: C

5. How many hydrogen atoms are there in nonane, the linear hydrocarbon with nine carbon atoms?
 - a. 16
 - b. 18
 - c. 20
 - d. 22

ANS: C

6. How many hydrogen atoms are there in dodecane, the linear hydrocarbon with twelve carbon atoms?
 - a. 12
 - b. 20
 - c. 24
 - d. 26

ANS: D

7. How many constitutional isomers are there with the molecular formula C_4H_{10} ?
- 2
 - 3
 - 4
 - 5

ANS: A

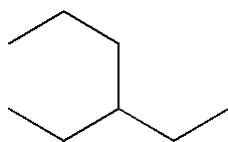
8. How many constitutional isomers are there with the molecular formula C_5H_{12} ?
- 2
 - 3
 - 4
 - 5

ANS: B

9. How many constitutional isomers are there with the molecular formula C_6H_{14} ?
- 3
 - 4
 - 5
 - 8

ANS: C

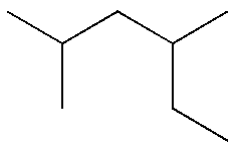
10. What is the IUPAC name of the following compound?



- 3-propylpentane
- 1,1-diethylpropane
- 3-ethylhexane
- isooctane

ANS: C

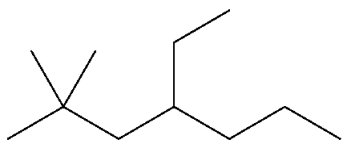
11. What is the IUPAC name of the following compound?



- 2-ethyl-4-methylpentane
- 2,4-dimethylhexane
- 3,5-dimethylhexane
- 1,1,3-trimethylpentane

ANS: B

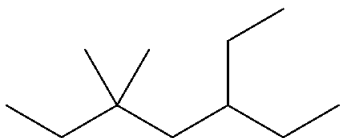
12. What is the IUPAC name of the following compound?



- a. 2,2-dimethyl-4-ethylheptane
- b. 4-ethyl-2,2-dimethyl-heptane
- c. 6,6-dimethyl-4-ethylheptane
- d. 4-ethyl-6,6-dimethyl-heptane

ANS: B

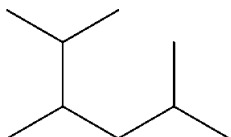
13. What is the IUPAC name of the following compound?



- a. 5,5-dimethyl-3-ethylheptane
- b. 5-ethyl-3,3-dimethyl-heptane
- c. 3,3-dimethyl-5-ethylheptane
- d. 3-ethyl-5,5-dimethyl-heptane

ANS: D

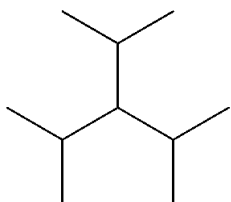
14. What is the IUPAC name of the following compound?



- a. 2-isopropyl-5-methylpentane
- b. 5-isopropyl-2-methylpentane
- c. 2,3,5-trimethylhexane
- d. 1,2-diisopropylpropane

ANS: C

15. What is the IUPAC name of the following compound?



- a. 2,4-dimethyl-3-isopropyl-pentane
- b. 3-isopropyl-1,5-dimethylpentane
- c. 3-isopropyl-2,4-dimethylpentane
- d. triisopropylmethane

ANS: C

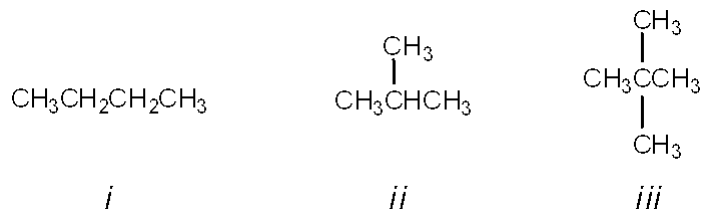
16. Which of the following compounds has 1°, 2°, 3° and 4° carbon atoms?
- hexane
 - 2-methylhexane
 - 2,2-dimethylhexane
 - 2,2,3-trimethylhexane

ANS: D

17. Which of the following compounds has only 1° and 3° carbon atoms?
- hexane
 - 2-methylpentane
 - 3-methylpentane
 - 2,3-dimethylbutane

ANS: D

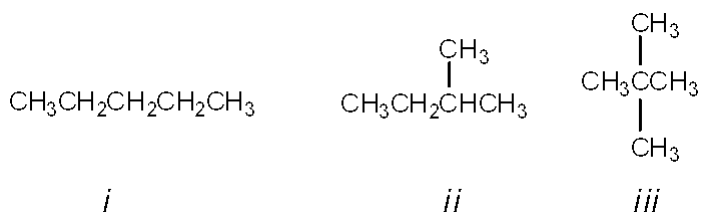
18. What is the correct assignment of common names for the following molecules?



- i* = butane; *ii* = neopentane; *iii* = isopentane
- i* = neobutane; *ii* = isobutane; *iii* = pentane
- i* = butane; *ii* = isobutane; *iii* = isopentane
- i* = butane; *ii* = isobutane; *iii* = neopentane

ANS: D

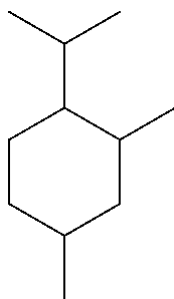
19. What is the correct assignment of common names for the following molecules?



- i* = pentane; *ii* = isopentane; *iii* = neopentane
- i* = neopentane; *ii* = isopentane; *iii* = pentane
- i* = pentane; *ii* = neopentane; *iii* = isopentane
- i* = neopentane; *ii* = pentane; *iii* = isopentane

ANS: A

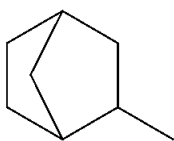
20. What is the IUPAC name of the following compound?



- a. 1-isopropyl-4,6-dimethylcyclohexane
- b. 1-isopropyl-2,4-dimethylcyclohexane
- c. 4-isopropyl-1,3-dimethylcyclohexane
- d. 4-isopropyl-1,5-dimethylcyclohexane

ANS: B

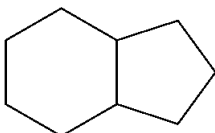
21. What is the IUPAC name of the following compound?



- a. 1-methylbicyclo[2.2.1]heptane
- b. 2-methylbicyclo[2.2.1]heptane
- c. 3-methylbicyclo[2.2.1]heptane
- d. 4-methylbicyclo[2.2.1]heptane

ANS: B

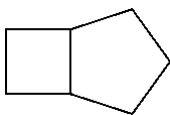
22. What is the IUPAC name of the following compound?



- a. bicyclo[4.3]nonane
- b. bicyclo[4.3.0]nonane
- c. bicyclo[6.5]nonane
- d. bicyclo[6.5.0]nonane

ANS: B

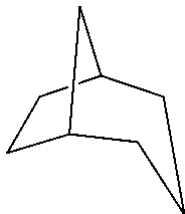
23. What is the IUPAC name for the following compound?



- a. cycloheptane
- b. bicyclo[3.2.0]heptane
- c. bicyclo[5.4]heptane
- d. cyclobutylcyclopentane

ANS: B

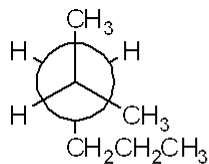
24. What is the IUPAC name for the following compound?



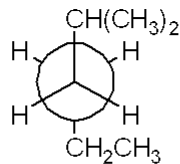
- a. bicyclo[5.4.3]octane
- b. bicyclo[3.2.1]octane
- c. bicyclo[3.2.1]hexane
- d. bicyclo[2.2.1]octane

ANS: B

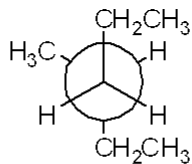
25. Which of the following Newman projections does *not* represent 2-methylhexane?



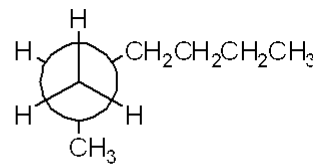
1



2



3

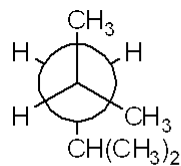


4

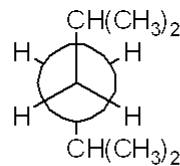
- a. **1**
- b. **2**
- c. **3**
- d. **4**

ANS: C

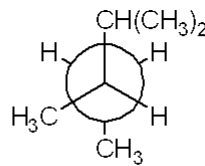
26. Which of the following Newman projections represents 2,4-dimethylpentane?



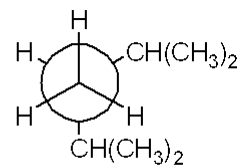
1



2



3

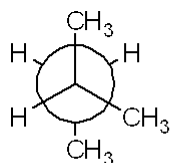


4

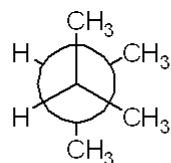
- a. **1**
- b. **2**
- c. **3**
- d. **4**

ANS: A

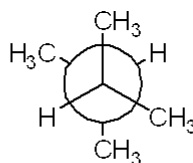
27. Which of the following Newman projections represents the most stable conformation of 2,3-dimethylbutane?



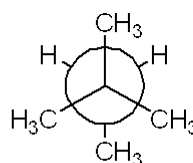
1



2



3

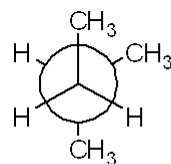


4

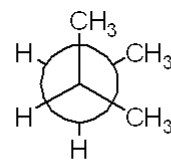
- a. **1**
 b. **2**
 c. **3**
 d. **4**

ANS: C

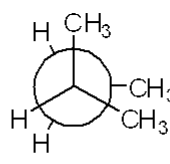
28. Which of the following Newman projections represents the most stable conformation of 2-methylbutane?



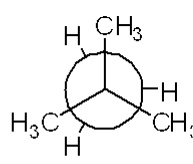
1



2



3



4

- a. **1**
 b. **2**
 c. **3**
 d. **4**

ANS: A

29. Which of the following cycloalkanes has the most ring strain?

- a. cyclopropane
 b. cyclobutane
 c. cyclopentane
 d. cyclohexane

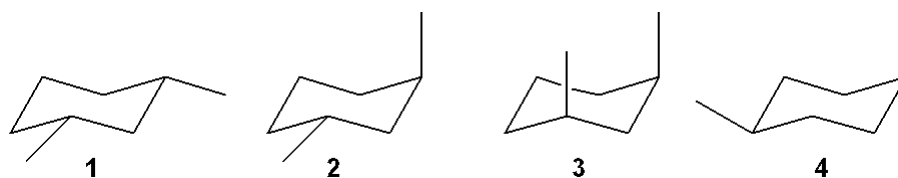
ANS: A

30. Which of the following cycloalkanes has the least ring strain?

- a. cyclopropane
 b. cyclopentane
 c. cyclohexane
 d. cycloheptane

ANS: C

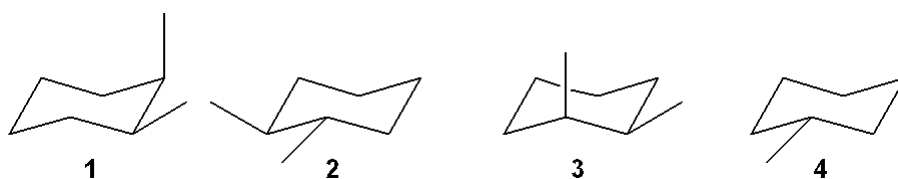
31. Which of the following structures represents *trans*-1,3-dimethylcyclohexane?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: B

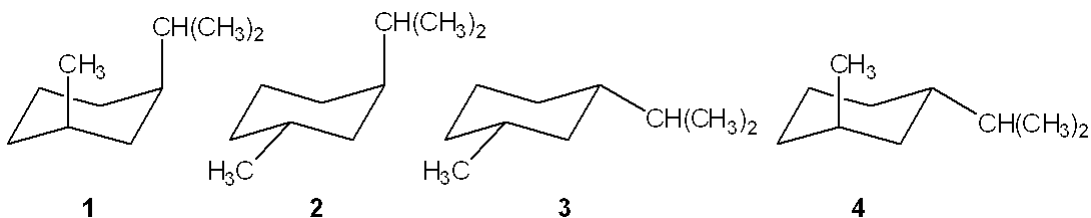
32. Which of the following structures represents *trans*-1,2-dimethylcyclohexane?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: B

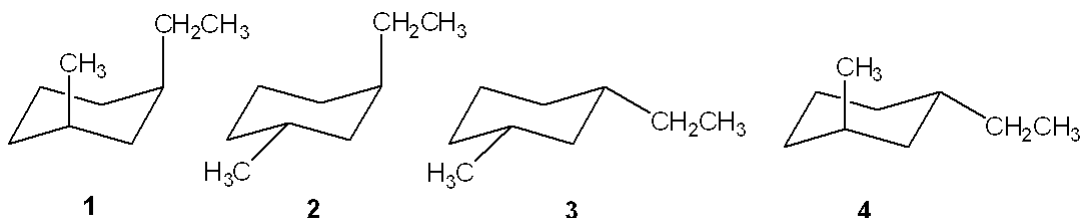
33. Which of the following is the most stable conformation of *cis*-1-isopropyl-3-methylcyclohexane?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: C

34. Which of the following is the most stable conformation of *trans*-1-ethyl-3-methylcyclohexane?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: D

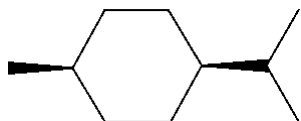
35. Which of the following alkanes has the highest boiling point?
- a. propane
 - b. butane
 - c. pentane
 - d. hexane

ANS: D

36. Which of the following alkanes has the highest boiling point?
- a. 2,3-dimethylbutane
 - b. 2-methylpentane
 - c. 3-methylpentane
 - d. hexane

ANS: D

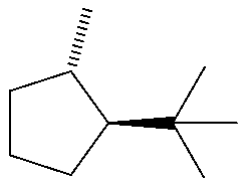
37. What is the IUPAC name of the following compound?



- a. *trans*-1-isopropyl-4-methylcyclohexane
- b. *cis*-1-isopropyl-4-methylcyclohexane
- c. *cis*-2-isopropyl-5-methylcyclohexane
- d. *cis*-1-*tert*-butyl-4-methylcyclohexane

ANS: B

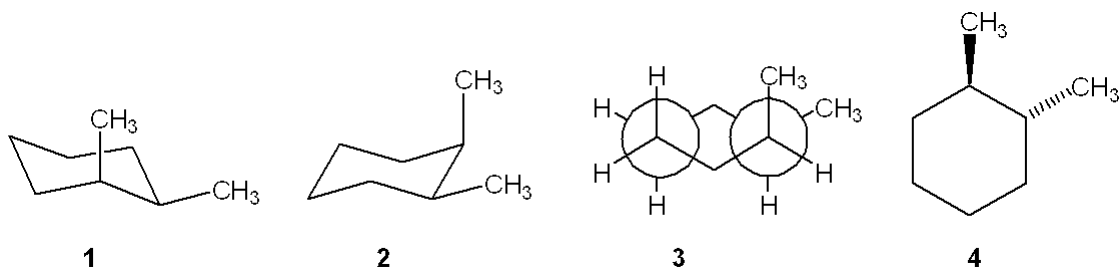
38. What is the IUPAC name of the following compound?



- a. *trans*-1-isopropyl-4-methylcyclopentane
- b. *cis*-1-*tert*-butyl-2-methylcyclopentane
- c. *trans*-1-*tert*-butyl-2-methylcyclopentane
- d. *cis*-1-isopropyl-2-methylcyclopentane

ANS: C

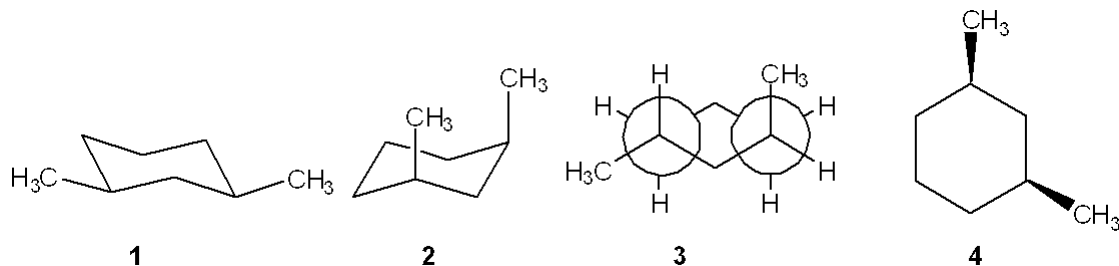
39. Which one of the following structures represents a different compound from the other three?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: D

40. Which one of the following structures represents a different compound from the other three?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: C

41. In which of the following compounds are all of the carbon atoms in the same plane?

- a. cyclopropane
- b. cyclobutane
- c. cyclopentane
- d. cyclohexane

ANS: A

42. Which of the following compounds can adopt a chair conformation in which there are no axial methyl groups?

- a. 1,1-dimethylcyclohexane
- b. *cis*-1,2-dimethylcyclohexane
- c. *trans*-1,2-dimethylcyclohexane
- d. *cis*-1,3-dimethylcyclohexane

ANS: C

43. Which of the following compounds can adopt a chair conformation in which there are no axial methyl groups?
- cis*-1,2-dimethylcyclohexane
 - cis*-1,3-dimethylcyclohexane
 - trans*-1,3-dimethylcyclohexane
 - cis*-1,4-dimethylcyclohexane

ANS: B

44. Which of the following statements is not true regarding the conformation of substituted cyclohexanes?
- ring inversion of cyclohexane between two chair conformations takes place via a boat conformation
 - substituted cyclohexanes are destabilized by 1,3-diaxial interactions
 - the boat conformation of cyclohexane is usually more stable than the chair conformation
 - the relative amount of two conformations of substituted cyclohexanes can be determined from the difference in strain energy

ANS: C

45. What is the approximate dihedral angle between the two chlorine atoms in *cis*-1,2-dichlorocyclohexane?
- 0°
 - 60°
 - 120°
 - 180°

ANS: B

46. What is the approximate dihedral angle between the two chlorine atoms in the diequatorial conformation of *trans*-1,2-dichlorocyclohexane?
- 0°
 - 60°
 - 120°
 - 180°

ANS: B

47. What is the approximate dihedral angle between the two chlorine atoms in the diaxial conformation of *trans*-1,2-dichlorocyclohexane?
- 0°
 - 60°
 - 120°
 - 180°

ANS: D

48. Which of the following is *not* true regarding the properties of alkanes?
- alkanes are nonpolar
 - alkanes burn in air to give H₂O and CO₂
 - alkanes are highly miscible with water
 - the strongest intermolecular force between alkane molecules is the van der Waals interaction

ANS: C

49. Which of the following undergoes the most exothermic combustion?
- octane
 - 2-methylheptane
 - 2,2-dimethylhexane
 - 2,2,3,3-tetramethylbutane

ANS: A

50. How many moles of molecular oxygen (O_2) are consumed in the complete combustion of one mole of octane (C_8H_{18})?
- 12.5
 - 13
 - 17
 - 26

ANS: A

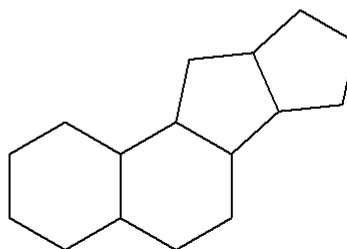
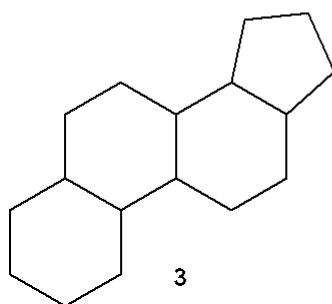
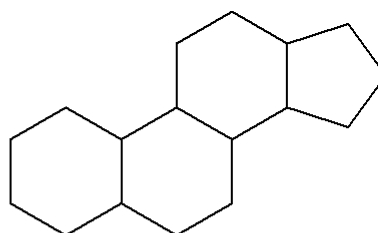
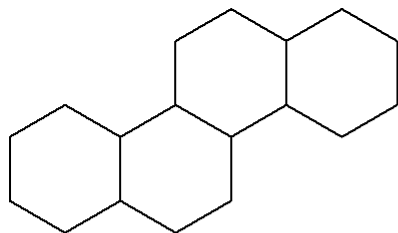
51. How many moles of molecular oxygen (O_2) are consumed in the complete combustion of one mole of hexane (C_6H_{14})?
- 6
 - 9.5
 - 12.5
 - 14

ANS: B

52. Which of the following statements is *not* true?
- Combustion of an alkane is an exothermic reaction.
 - The heat of combustion of propane is three times that of methane.
 - The constitutional isomers of C_7H_{16} have different heats of combustion from one another.
 - The products of combustion of an alkane are H_2O and CO_2 .

ANS: B

53. Which of the following is the steroid nucleus?



- a. 1
- b. 2
- c. 3
- d. 4

ANS: B

54. Which of the following cycloalkanes has the largest heat of combustion?

- a. cyclopropane
- b. cyclobutane
- c. cyclopentane
- d. cyclohexane

ANS: D

55. Which of the following cycloalkanes has the largest heat of combustion per carbon atom?

- a. cyclopropane
- b. cyclopentane
- c. cyclohexane
- d. cycloheptane

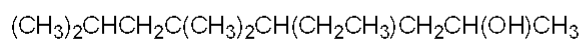
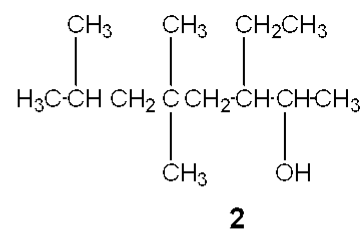
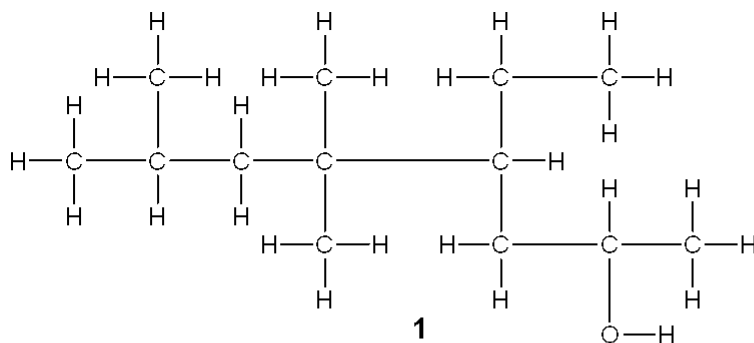
ANS: A

56. Which of the following cycloalkanes has the smallest heat of combustion per carbon atom?

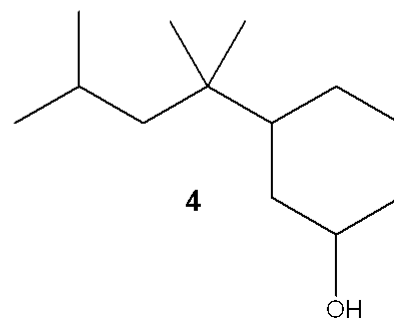
- a. cyclopropane
- b. cyclopentane
- c. cyclohexane
- d. cycloheptane

ANS: C

57. Which of the following structures is different from the other three?



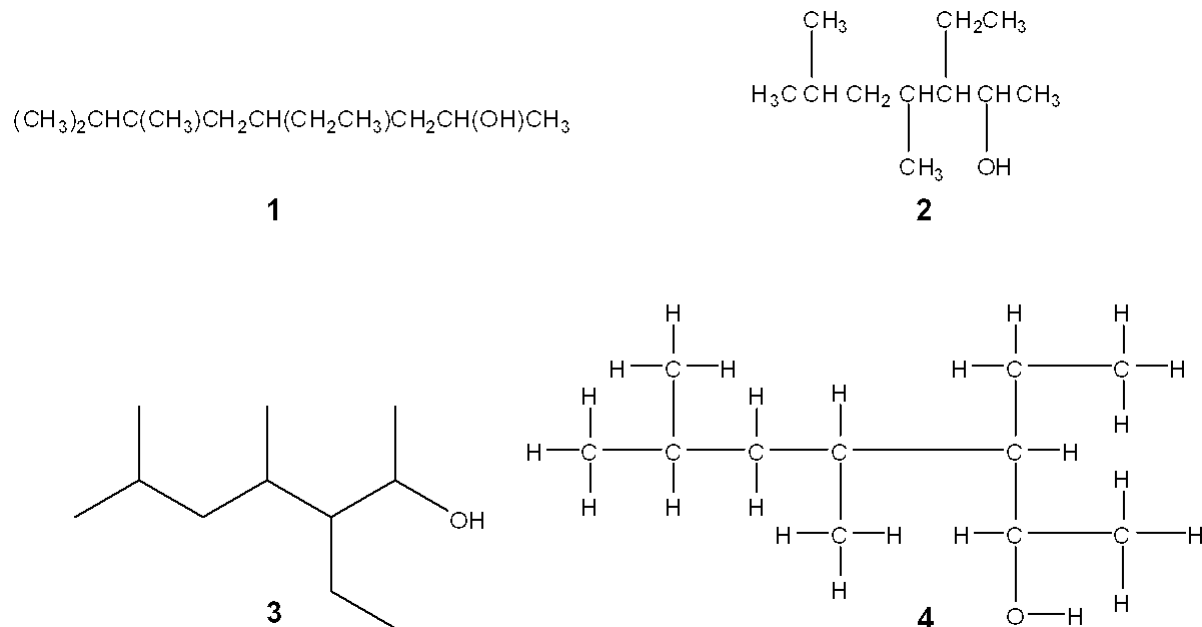
3



- a. **1**
- b. **2**
- c. **3**
- d. **4**

ANS: B

58. Which of the following structures is different from the other three?



- a. **1**
- b. **2**
- c. **3**
- d. **4**

ANS: A

59. Which of the following substituted cyclohexanes has the most negative value of ΔG° for ring flipping from the conformation in which the substituent is axial to the one where it is equatorial?

- a. methylcyclohexane
- b. chlorocyclohexane
- c. isopropylcyclohexane
- d. ethynylcyclohexane

ANS: C

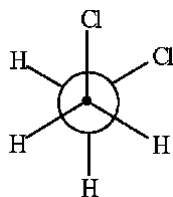
60. Which of the following substituted cyclohexanes has the most negative value of ΔG° for ring flipping from the conformation in which the substituent is axial to the one where it is equatorial?

- a. fluorocyclohexane
- b. methylcyclohexane
- c. ethylcyclohexane
- d. *tert*-butylcyclohexane

ANS: D

TRUE/FALSE

1. The Newman projection of the gauche conformation of 1,2-dichloroethane is shown below.

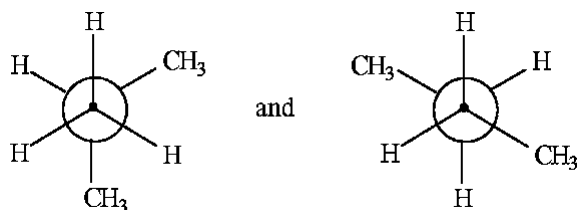


ANS: T

2. The most stable conformation of an alkane occurs when carbon-carbon bonds are staggered and bulky groups are anti.

ANS: T

3. The following pairs of Newman projections represent the same compound but in differing conformations.

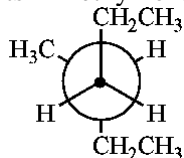


ANS: F

4. There are four constitutional isomers for the molecular formula C_6H_{14} .

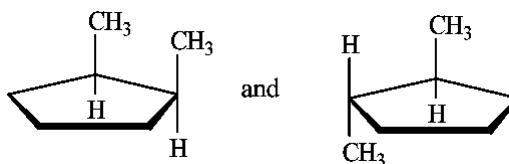
ANS: F

5. The following Newman projection represents 2-methylhexane.



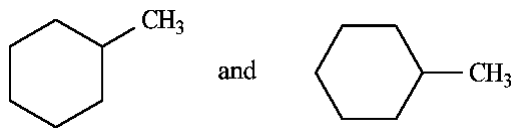
ANS: F

6. The following structures represent, from left to right, a *cis* and a *trans* isomer.



ANS: T

7. The following structures represent a pair of constitutional isomers.

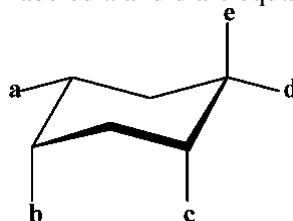


ANS: F

8. 3-methylhexylcyclopentane represents a correct IUPAC name.

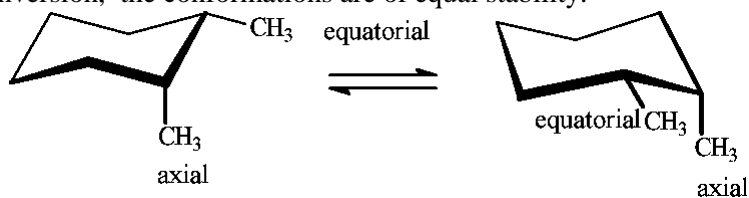
ANS: F

9. In the following structure the positions labeled a and d are equatorial positions.



ANS: T

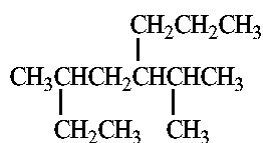
10. In the following conversion, the conformations are of equal stability.



ANS: T

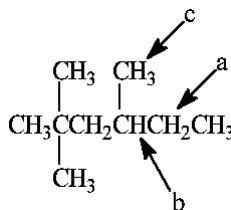
COMPLETION

1. The correct IUPAC name for the following compound is _____.



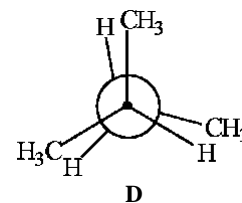
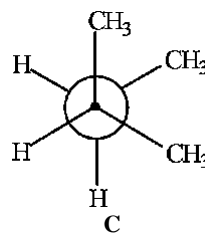
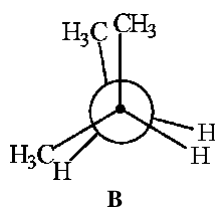
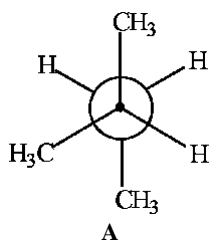
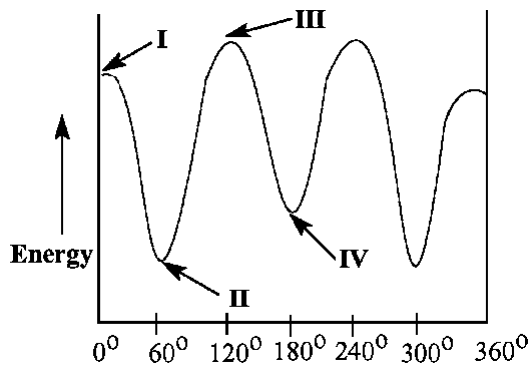
ANS: 3-methyl-5-(1-methylethyl)octane 3-methyl-5-isopropyloctane

2. The tertiary carbon atom in the following structure is indicated by the letter _____.



ANS: b

Match the Newman projection for the conformation of 2-methylbutane to the indicated position on the potential energy diagram.



3. Conformation A is represented by Roman numeral ____.

ANS: II

4. Conformation B is represented by Roman numeral ____.

ANS: III

5. Conformation C is represented by Roman numeral ____.

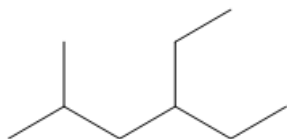
ANS: IV

6. Conformation D is represented by Roman numeral ____.

ANS: I

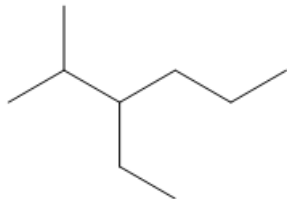
PROBLEM

1. What is the IUPAC name of the following compound?



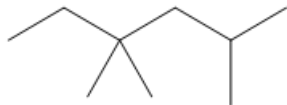
ANS: 4-ethyl-2-methylhexane

2. What is the IUPAC name of the following compound?



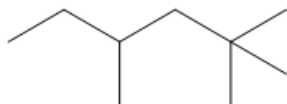
ANS: 3-ethyl-2-methylhexane

3. What is the IUPAC name of the following compound?



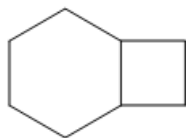
ANS: 2,4,4-trimethylhexane

4. What is the IUPAC name of the following compound?



ANS: 2,2,4-trimethylhexane

5. What is the IUPAC name of the following compound?



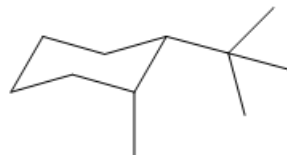
ANS: bicyclo[4.2.0]octane

6. What is the IUPAC name of the following compound?



ANS: bicyclo[2.2.1]heptane

7. What is the IUPAC name of the following compound?



ANS: *cis*-1-*tert*-butyl-2-methylcyclohexane

[ignoring absolute stereochemistry in Chap 2]

8. What is the IUPAC name of the following compound?



ANS: *cis*-1-isopropyl-3-methylcyclohexane

[ignoring absolute stereochemistry in Chap 2]

9. How many hydrogen atoms are there in decane?

ANS: 22

10. How many hydrogen atoms are there in octane?

ANS: 18

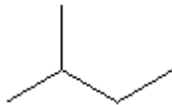
11. What are the common and IUPAC names of the following compound?



ANS: *common*: neopentane

IUPAC: 2,2-dimethylpropane

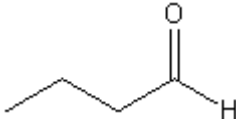
12. What are the common and IUPAC names of the following compound?



ANS: *common*: isopentane

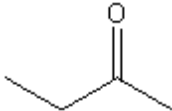
IUPAC: 2-dimethylbutane

13. What is the IUPAC name of the following compound?



ANS: butanal

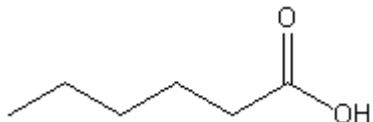
14. What is the IUPAC name of the following compound?



ANS: butanone

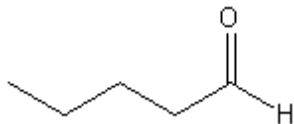
15. Provide a line-bond structure of hexanoic acid.

ANS:



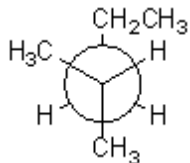
16. Provide a line-bond structure of pentanal.

ANS:



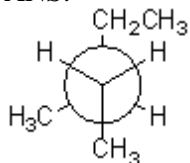
17. Provide a Newman projection of the most stable conformation of 2-methylpentane, $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}_3$, looking along the C2-C3 bond

ANS:

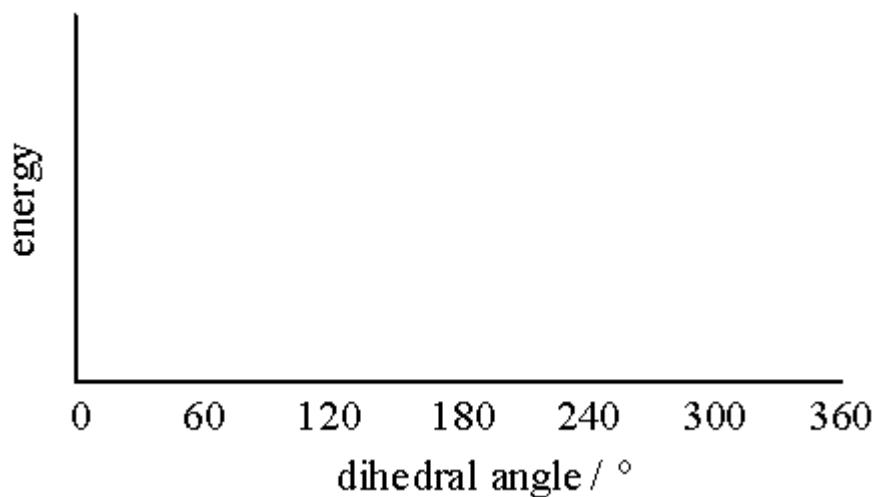


18. Provide a Newman projection of the most stable conformation of 3-methylpentane, $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ looking along the C2-C3 bond.

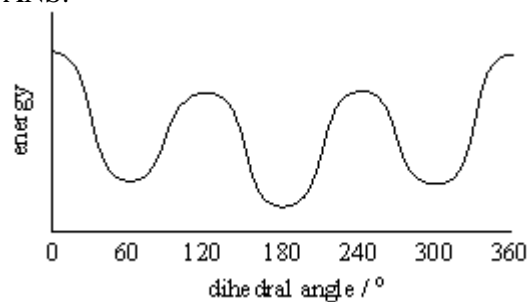
ANS:



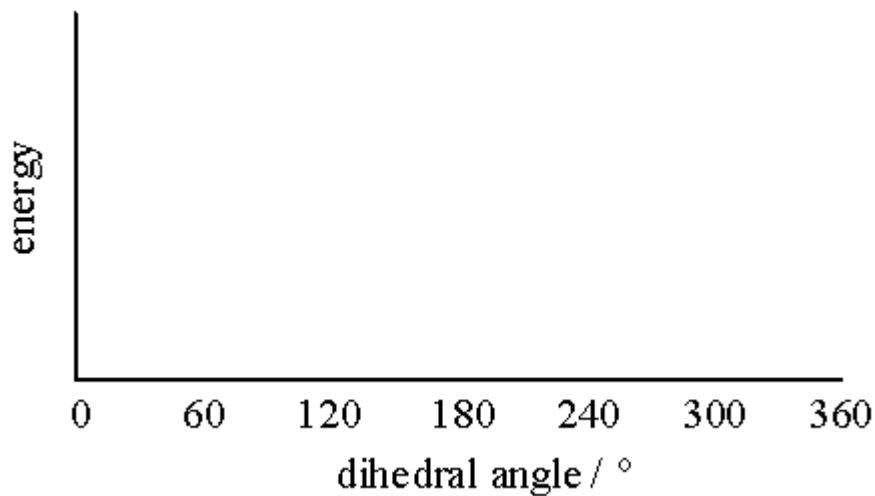
19. Provide a neatly drawn plot of energy versus dihedral angle for rotation around the C2-C3 bond of butane.



ANS:



20. Provide a neatly drawn plot of energy versus dihedral angle for rotation around the C-C bond of ethane.



ANS:

