

## Chapter 2: Alkanes

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### LEARNING OBJECTIVES

Recognize functional groups

Multiple Choice: 1

Short Answer: 1

Create hybrid orbitals from atomic orbitals

Multiple Choice: 2, 3

Short Answer: 4

Understand %s character

Multiple Choice: 4

Short Answer: 5

Understand bonding in methane and derivatives

Multiple Choice: 5, 6

Short Answer: 2

Draw Newman projections

Multiple Choice: 7, 8, 15, 19-21, 30

Short Answer: 8-10, 12, 14

Understand conformational preferences of ethane

Multiple Choice: 9

Short Answer: 11

Interpret line drawings

Multiple Choice: 10, 11

Recognize constitutional isomers

Multiple Choice: 12-14

Identify degrees of carbon attachment

Multiple Choice: 16-18

Short Answer: 13, 20

Interconvert IUPAC nomenclature and molecular structure

Multiple Choice: 22-24

Short Answer: 15-18, 21

Explain how molecular shape impacts boiling/melting points

Multiple Choice: 26, 27

Determine the expected number of  $^{13}\text{C}$  NMR signals

Multiple Choice: 28, 31

Short Answer: 27, 28

Determine the expected number and ratio of  $^1\text{H}$  NMR signals

Multiple Choice: 29

Short Answer: 25, 26

Recognize hybridization states

Short Answer: 3, 6, 7

Draw all isomers of a given molecular formula

Short Answer: 19, 22-24

Use the curved arrow formalism

Short Answer: 31, 32

Recognize Lewis acids and bases

Short Answer: 29, 30, 33, 34

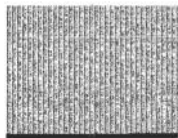
Understand molecular unsaturation

Multiple Choice: 25

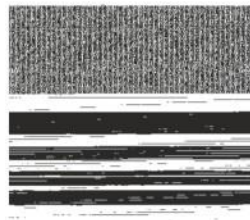
## MULTIPLE CHOICE

1. Which molecule contains a ketone?

a.



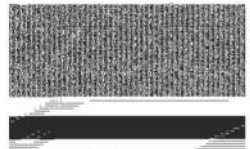
d.



b.



e.



c.



ANS: D

DIF: Easy

REF: 2.1

OBJ: Recognize functional groups

MSC: Remembering

2. Which combination of atomic orbitals will produce an  $sp^2$  hybrid orbital?

a.  $2p_x + 1s$

d.  $2p_x + 2p_z + 2s$

b.  $2p_x + 2s$

e.  $2p_x + 2p_y + 2p_z + 2s$

c.  $2p_x + 2p_y + 2p_z$

ANS: D

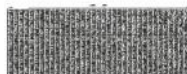
DIF: Easy

REF: 2.2

OBJ: Create hybrid orbitals from atomic orbitals

MSC: Remembering

3. Dibromocarbene is an example of a chemical species called a carbene



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

a.  $sp$

d.  $2s$

b.  $sp^2$

e.  $2p$

c.  $sp^3$

ANS: B

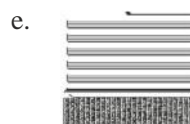
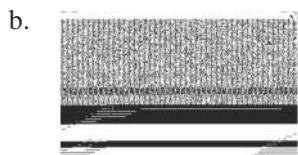
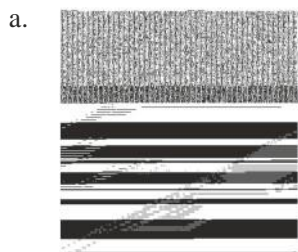
DIF: Difficult

REF: 2.2

OBJ: Create hybrid orbitals from atomic orbitals

MSC: Applying

4. Which structure contains a hybrid orbital with a higher %*s* character than the hybrids found in any of the others?



ANS: B                      DIF: Easy                      REF: 2.2                      OBJ: Understand %*s* character  
MSC: Analyzing

5. Which of the following statements about methane, CH<sub>4</sub>, is *false*?

- The carbon-hydrogen bonds in methane are formed by the combination of an *sp*<sup>3</sup> orbital on carbon and a 1*s* orbital on hydrogen.
- The C—H bonding molecular orbital has cylindrical symmetry.
- The C—H antibonding molecular orbital does not have cylindrical symmetry.
- The hybrid orbitals on carbon are 25% *s* character and 75% *p* character.
- All bond angles are 109.5°.

ANS: C                      DIF: Medium                      REF: 2.2                      OBJ: Understand bonding in methane and derivatives                      MSC: Understanding

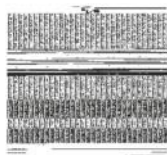
6. Which statement about bonding in the ammonium ion (<sup>+</sup>NH<sub>4</sub>) is *false*?

- The molecule is tetrahedral.
- There are four bonding molecular orbitals.
- There are four antibonding molecular orbitals.
- All bonding orbitals are occupied.
- The N hybrid orbitals are made by combining 2*p*<sub>*x*</sub>, 2*p*<sub>*y*</sub>, and 2*s* atomic orbitals.

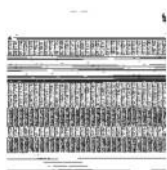
ANS: E                      DIF: Difficult                      REF: 2.2                      OBJ: Understand bonding in methane and derivatives                      MSC: Understanding

7. Which of the following Newman projections shows a dihedral angle of  $60^\circ$  between  $H_A$  and  $H_B$ ?

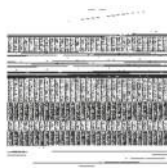
a.



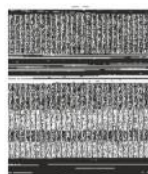
b.



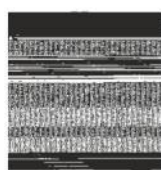
c.



d.



e.



ANS: E

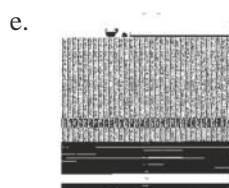
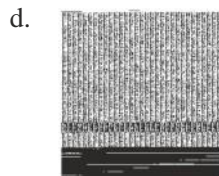
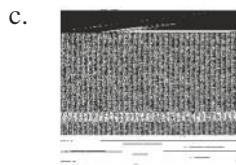
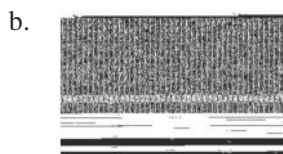
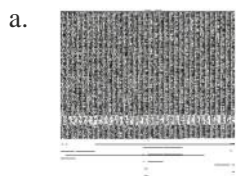
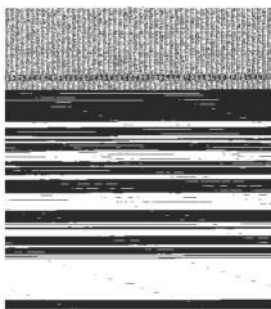
DIF: Easy

REF: 2.5

OBJ: Draw Newman projections

MSC: Understanding

8. Which of the following structures is a depiction of structure A?



ANS: A                      DIF: Difficult                      REF: 2.5  
 OBJ: Draw Newman projections                      MSC: Analyzing

9. Which of the following statements about ethane is *false*?

- Staggered ethane is destabilized by interactions between filled C—H  $\sigma$  and empty C—H  $\sigma^*$  orbitals.
- Staggered ethane is stabilized by interactions between filled C—H  $\sigma$  and empty C—H  $\sigma^*$  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 eclipsed conformation is stabilized by interactions between filled C—H  $\sigma$  bonds.

ANS: A                      DIF: Difficult                      REF: 2.5  
 OBJ: Understand conformational preferences of ethane                      MSC: Analyzing

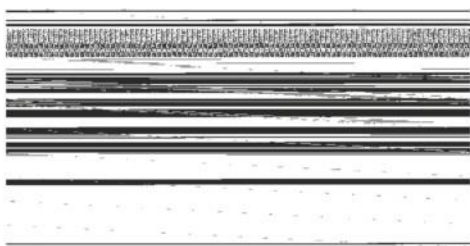
10. Which of these structures represent the *same* compound?



- a. I and II
- b. I and III
- c. II and III
- d. I, II, and III
- e. They are all different compounds.

ANS: B                      DIF: Easy                      REF: 2.6                      OBJ: Interpret line drawings  
 MSC: Understanding

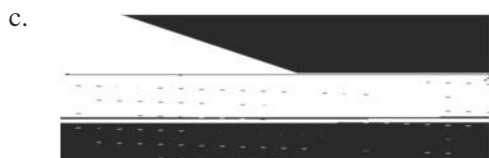
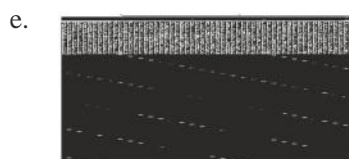
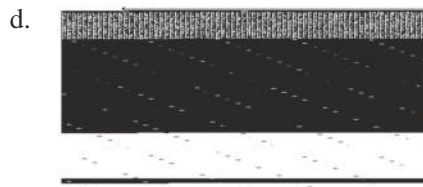
11. Which of the following line structures corresponds to the Lewis structure shown here?



- a.
- b.
- c.
- d.
- e.

ANS: E                      DIF: Medium                      REF: 2.6                      OBJ: Interpret line drawings  
 MSC: Understanding

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



ANS: D

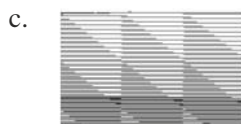
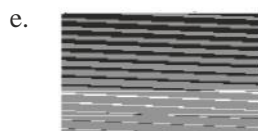
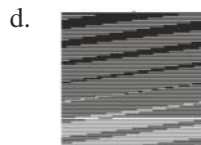
DIF: Easy

REF: 2.7

OBJ: Recognize constitutional isomers

MSC: Understanding

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



ANS: B

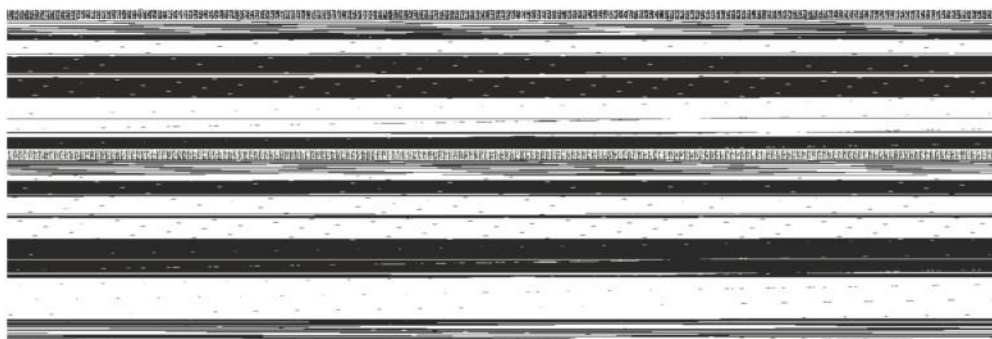
DIF: Easy

REF: 2.7

OBJ: Recognize constitutional isomers

MSC: Understanding

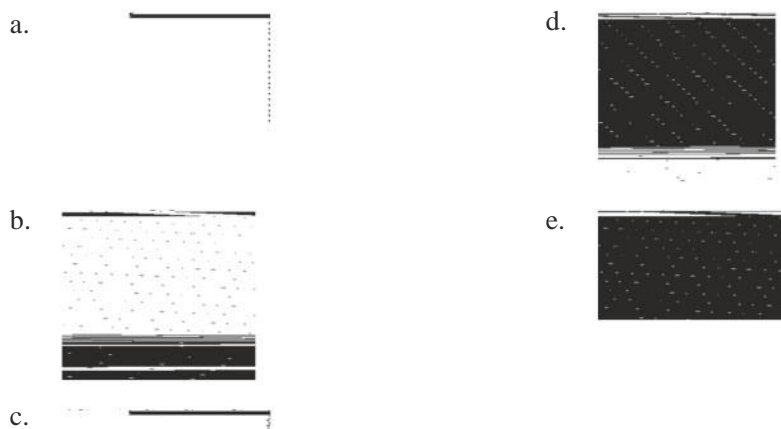
14. Which of the following compounds are pairs of constitutional isomers?



- a. I and IV  
 b. I and III  
 c. II and III  
 d. II and IV  
 e. I and II

ANS: B                    DIF: Easy                    REF: 2.7  
 OBJ: Recognize constitutional isomers                    MSC: Analyzing

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



ANS: B                    DIF: Medium                    REF: 2.7  
 OBJ: Draw Newman projections                    MSC: Applying