3-33
(a) The third structure is 2-methylpropane (isobutane). The other four structures are all n-butane. Remember that a compound’s identity is determined by how the atoms are connected, not by the position of the atoms when a structure is drawn on a page.

(b) The two structures at the top-left and bottom-left are both cis-2-butene. The two structures at the top-center and bottom-center are both 1-butene. The unique structure at the upper right is trans-2-butene. The unique structure at the lower right is 2-methylpropene.

(c) The first two structures are both cis-1,2-dimethylcyclopentane. The next two structures are both trans-1,2-dimethylcyclopentane. The last structure is different from all the others, cis-1,3-dimethylcyclopentane.

(d)

```
   H  H
  /   /
 A   A
    /
   H  H
```

```
   H  H
  /   /
 A   A
    /
   H  H
```

```
    H
   /  
 B   H
```

```
    H
   /  
 C   H
```

```
    H
   /  
 D   H
```

Analysis of the structures shows that some double bonds begin at carbon-2 and some at carbon-3 of the longest chain.

The three structures labeled A are the same, with the double bond trans; B is a geometric isomer (cis) of A. C and D are constitutional isomers of the others.

(e) Naming the structures shows that three of the structures are trans-1,4-dimethylcyclohexane, two are the cis isomer, and one is cis-1,3-dimethylcyclohexane. Although a structure may be shown in two different conformations, it still represents only one compound.

```
H3C  CH3
H    H
   
 cis-1,4-dimethyl
```

```
H3C  CH3
H    H
   
trans-1,4-dimethyl
```

```
H3C  CH3
H    H
   
 cis-1,3-dimethyl
```

```
H3C  CH3
H    H
   
trans-1,4-dimethyl
```

```
H3C  CH3
H    H
   
 cis-1,4-dimethyl
```

```
H3C  CH3
H    H
   
trans-1,4-dimethyl
```
3-34 Line formulas are shown.

(a) \[ \text{chemical structure} \]
(b) \[ \text{chemical structure} \]
(c) \[ \text{chemical structure} \]
(d) \[ \text{chemical structure} \]
(e) \[ \text{chemical structure} \]
(f) \[ \text{chemical structure} \]
(g) \[ \text{chemical structure} \]
(h) \[ \text{chemical structure} \]
(i) \[ \text{chemical structure} \]
(j) \[ \text{chemical structure} \]
(k) \[ \text{chemical structure} \]
(l) \[ \text{chemical structure} \]

3-35 There are many possible answers to each of these problems. The ones shown here are examples of correct answers. Your answers may be different AND correct. Check your answers in your study group.

(a) 2-methylheptane  3-methylheptane  or  4-methylheptane

(b) 4,5-diethyldecane  3,5-diethyldecane  (Any combination is correct except using position numbers 1 or 2 or 9 or 10. Why won't these work?)

(c) \[ \text{chemical structure} \]  \[ \text{chemical structure} \]  \[ \text{chemical structure} \]

\[ \text{cis}-1,2\text{-diethylcycloheptane} \]  \[ \text{cis}-1,3\text{-diethylcycloheptane} \]  \[ \text{cis}-1,4\text{-diethylcycloheptane} \]

(d) only two possible answers

\[ \text{chemical structure} \]  \[ \text{chemical structure} \]

\[ \text{trans}-1,2\text{-dimethylcyclopentane} \]  \[ \text{trans}-1,3\text{-dimethylcyclopentane} \]
3-35 continued

(e) \(\text{(2,3-dimethylpentyl)cycloheptane}\)

(2,3-dimethylpentyl)cyclooctane

Other ring sizes are possible, although they must have 6 or more carbons to be longer than the 5 carbons of the substituent chain.

(f) \(\text{bicyclo[4.4.0]decane}\)

\(\text{bicyclo[3.3.2]decane}\)

Any combination where the number of carbons in the bridges sums to 8 will work. (Two carbons are the bridgehead carbons.)

3-36

\(\text{HO-CH}_3\)

\(\text{HO-CH}_2\text{CH}_2\text{CH}_3\)

\(\text{HO-CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\)

\(\text{HO-CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\)

3-37

(a) \(\text{3-ethyl-2,2,6-trimethylheptane}\)

(b) \(\text{3-ethyl-2,6,7-trimethyloctane}\)

(c) \(\text{3,7-dieethyl-2,2,8-trimethyldecane}\)

(d) \(\text{2-ethyl-1,1-dimethylcyclobutane}\)

(e) \(\text{bicyclo[4.1.0]heptane}\)

(f) \(\text{cis-1-ethyl-3-propylcyclopentane}\)

(g) \(\text{(1,1-dieethylpropyl)cyclohexane}\)

(h) \(\text{cis-1-ethyl-4-isopropylcyclodecane}\)

3-38 There are eighteen isomers of \(\text{C}_8\text{H}_{18}\). Here are eight of them. Yours may be different from the ones shown. An easy way to compare is to name yours and see if the names match.

\(\text{n-octane}\)

2-methylheptane

2,3-dimethylhexane

3-ethylhexane

2,2,4-trimethylpentane

2,3,4-trimethylpentane

3-ethyl-3-methylpentane

2,2,3,3-tetramethylbutane

3-39

(a)\[
\begin{array}{c}
\text{correct name: } \text{3-methylhexane} \\
\text{(longer chain)}
\end{array}
\]

(b)\[
\begin{array}{c}
\text{correct name: } \text{3-ethyl-2-methylhexane} \\
\text{(more branching with this numbering)}
\end{array}
\]

(c)\[
\begin{array}{c}
\text{correct name: } \text{2-chloro-3-methylhexane} \\
\text{(begin numbering at end closest to substituent)}
\end{array}
\]

(d)\[
\begin{array}{c}
\text{correct name: } \text{2,2-dimethylbutane} \text{ (include} \\
\text{a position number for each substituent,} \\
\text{regardless of redundancies)}
\end{array}
\]
3-39 continued

(e) \[ \text{correct name: sec-butylcyclohexane or (1-methylpropyl)cyclohexane} \]
(the longer chain or ring is the base name)

(f) \[ \text{correct name: 1,2-diethylcyclopentane} \]
(position numbers are the lowest possible)

3-40

(a) \( n \)-Octane has a higher boiling point than 2,2,3-trimethylpentane because linear molecules boil higher than branched molecules of the same molecular weight (increased van der Waals interaction).

(b) 2-Methylnonane has a higher boiling point than \( n \)-heptane because it has a significantly higher molecular weight than \( n \)-heptane.

(c) \( n \)-Nonane boils higher than 2,2,5-trimethylhexane for the same reason as in (a).

3-41 The point of attachment is shown by the bold bond at the left of each structure.

\[
\begin{align*}
\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_2\text{CH}_2\text{CH}_3 \\
1^\circ & \quad 2^\circ 1^\circ & \quad 1^\circ \\
\text{n-pentyl} & \quad \text{1-methylbutyl} & \quad \text{2-methylbutyl}
\end{align*}
\]

\[
\begin{align*}
\text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_3 \quad \text{C-CH}_2\text{CH}_3 \\
1^\circ & \quad 2^\circ 1^\circ & \quad 3^\circ 1^\circ \\
\text{CH}_3 & \quad \text{1-ethylpropyl} & \quad \text{1,1-dimethylpropyl} \\
\text{(isopentyl)} & & \text{(t-pentyl)}
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3 \\
2^\circ \text{CH}_3 & \quad 1^\circ \text{CH}_3 & \quad \text{CH}_3 \\
\text{1,2-dimethylpropyl} & \quad \text{2,2-dimethylpropyl} & \quad \text{(neo-pentyl)}
\end{align*}
\]

3-42 In each case, put the largest groups on adjacent carbons in anti positions to make the most stable conformations.

(a) 3-methylpentane

C-2 is the front carbon with H, H, and CH\(_3\)
C-3 is the back carbon with H, CH\(_3\), and CH\(_2\)CH\(_3\)
3-42 continued
(b) 3,3-dimethylhexane

C-3 is the front carbon with CH₃, CH₃, and CH₂CH₃
C-4 is the back carbon with H, H, and CH₂CH₃

3-43
(a) axial
   \[ \text{CH}_3 \]
   equatorial
   \[ \text{CH}_3 \]
f. axial

(b) more stable
    (lower energy)
    less stable
    (higher energy)

(c) From Section 3-14 of the text, each gauche interaction raises the energy 3.8 kJ/mole (0.9 kcal/mole), and each axial methyl has two gauche interactions, so the energy is:
    2 methyls × 2 interactions per methyl × 3.8 kJ/mole per interaction = 15.2 kJ/mole (3.6 kcal/mole)

(d) The steric strain from the 1,3-diaxial interaction of the methyls must be the difference between the total energy and the energy due to gauche interactions:
    \[ 23 \text{ kJ/mole} - 15.2 \text{ kJ/mole} = 7.8 \text{ kJ/mole} \]
    \[ (5.4 \text{ kcal/mole} - 3.6 \text{ kcal/mole} = 1.8 \text{ kcal/mole}) \]

3-44 The more stable conformer places the larger group equatorial.

(a) \[ \text{CH(\text{CH}_3)}_2 \]
   \[ \text{CH}_2\text{CH}_3 \]

(b) \[ \text{CH(\text{CH}_3)}_2 \]
   \[ \text{a CH}_2\text{CH}_3 \]

(c) \[ \text{a CH}_3 \]
   \[ \text{a CH}_2\text{CH}_3 \]
3-44 continued

(d)

(e)

more stable

more stable

3-45 (Using models is essential to this problem.)

In both cis- and trans-decalin, the cyclohexane rings can be in chair conformations. The relative energy will depend on the number of axial substituents.

trans
no axial substituents
MORE STABLE

cis
one axial substituent

3-46 chair form of glucose—all substituents equatorial

(without ring H's shown)