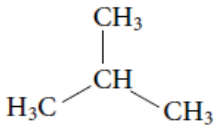
Unit 1 Organic Chemistry

Solutions to Practice Problems in Chapter 1 Structure and Physical Properties of Organic Compounds

Naming Alkanes
(Student textbook page 19)

1. Name the following molecule:



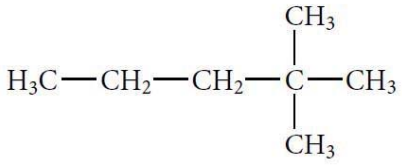
What Is Required?
You must name the given alkane.

What Is Given?
You are given the condensed structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is three carbons long, so the root is prop-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	A methyl group is attached to carbon 2. (This is the case if you start numbering from either end.) The prefix is 2-methyl-.
Write the name.	The full name is 2-methylpropane.

Check Your Solution
The name indicates the largest chain is 3 carbons long, which it is. The name indicates there is a methyl group on the second carbon, which is correct. All bonds are single bonds.

2. Name the following molecule:



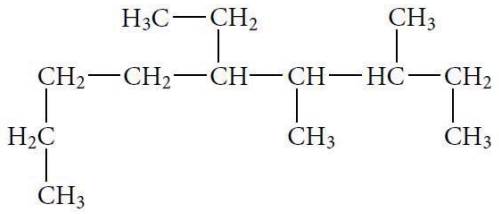
What Is Required?
You must name the given alkane.

What Is Given?
You are given the condensed structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is five carbons long, so the root is pent-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	Numbering must start at the end nearest the side groups thus giving the side groups the lowest possible numbers. There are two methyl groups bonded to the number 2 carbon, so the prefix is preceded by 2,2-. The two groups are identical, so the multiplying prefix is di-. The complete prefix is 2,2-dimethyl-.
Write the name.	The full name is 2,2-dimethylpentane.

Check Your Solution
The name indicates the largest chain is 5 carbons long, which it is. The prefix indicates there are 2 methyl groups on the second carbon, which is correct. All bonds are single bonds.

3. Name the following molecule:



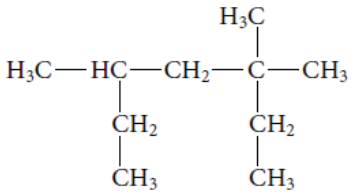
What Is Required?
You must name the given alkane.

What Is Given?
You are given the condensed structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is nine carbons long, so the root is non-.
Find the suffix.	The compound is an alkane so the suffix is -ane.
Find the prefix.	The main chain is numbered so that the side groups have the lowest possible numbers. Use multiplying prefixes to identify identical groups. Name the side groups alphabetically, ignoring the multiplying prefixes such as di-. The prefix would be 5-ethyl-3,4-dimethyl-.
Write the name.	The full name is 5-ethyl-3,4-dimethylnonane.

Check Your Solution
The name indicates the largest chain is 9 carbons long, which it is. The prefix indicates there is an ethyl group on carbon 5 and 2 methyl groups on carbons 3 and 4, which is correct. The numbering is based on the alphabetic order of the side chains without the multiplying prefixes. All bonds are single bonds.

4. Name the following molecule:



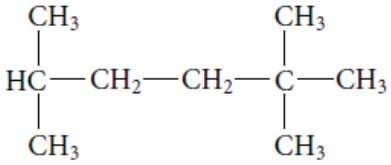
What Is Required?
You must name the given alkane.

What Is Given?
You are given the condensed structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is seven carbons long, so the root is hept-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	There are three methyl groups bonded to the main chain. Number the main chain to give the side groups the lowest number. Use numbers separated by commas to indicate the location of the side chains and use multiplying prefixes to indicate the number of identical groups. The prefix would be 3,3,5-trimethyl-.
Write the name.	The full name is 3,3,5-trimethylheptane.

Check Your Solution
The name indicates the longest chain is seven carbons long, which it is. The prefix indicates there are three methyl groups, two on carbon 3, the other on carbon 5, which is correct. All bonds are single bonds.

5. Name the following molecule:



What Is Required?
You must name the given alkane.

What Is Given?
You are given the condensed structural formula.

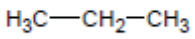
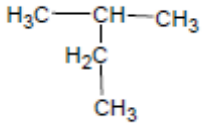
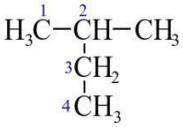
Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is six carbons long, so the root is hex-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	There are three methyl groups bonded to the main chain. Number the main chain to give the sum of the numbers of the side groups the lowest possible number. Use numbers separated by commas to indicate the location of the side chains and use multiplying prefixes to indicate the number of identical groups. The prefix would be 2,2,5-trimethyl- .
Write the name.	The full name is 2,2,5-trimethylhexane.

Check Your Solution
The name indicates the longest chain is six carbons long, which it is. The prefix indicates there are three methyl groups, two on carbon 2, the other on carbon 5, which is correct. All bonds are single bonds.

6. Identify any errors in the structure by drawing them. Rename the structure correctly.
2-ethylpropane

What Is Required?
You are to identify the errors in the name by drawing the structure and renaming it correctly.

What Is Given?
You are given an incorrectly named alkane.

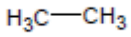
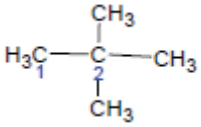
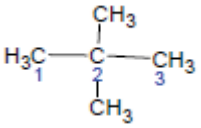
Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is prop- and is therefore three carbons long. It ends in -ane and therefore the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 2-ethyl, so there is a two-carbon group bonded to the number 2 carbon of the propane main chain. 
Find the correct root and suffix. Name the main chain.	The longest chain is four carbons long—not three, so the root name is but-, not prop-. The root name is butane. 
Identify the prefix. Number and name the side groups.	There is only one side group, which is one carbon long. The methyl group would be given the lowest number, which is two.
Write the name.	The full name is 2-methylbutane.

Check Your Solution
The four carbon atoms are the longest chain, which agrees with the root but-. The one carbon methyl group is numbered to give the lowest number on the main chain, so 2-methyl is correct. All the bonds are single bonds, so the suffix is correct.

7. Identify any errors in the structure by drawing them. Rename the structure correctly.
2,2,2-trimethylethane

What Is Required?
You are to identify the errors in the name by drawing the structure and renaming it correctly.

What Is Given?
You are given an incorrectly named alkane.

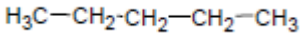
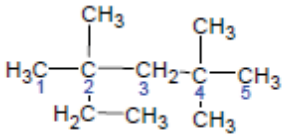
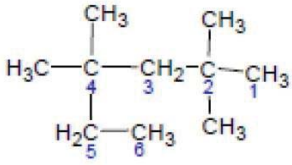
Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is eth- and is therefore two carbons long. It ends in -ane, and, therefore, the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 2,2,2-trimethyl, so there are 3 one-carbon groups bonded to the number 2 carbon of the ethane main chain. 
Find the correct root and suffix. Name the main chain.	The longest chain is three carbons long—not two, so the root name is prop-, not eth-. The root name is propane. 
Identify the prefix. Number and name the side groups.	There are two side groups that are one carbon long. The methyl groups would be given the lowest number, which is two—regardless of numbering from the left or right.
Write the name.	The full name is 2,2-dimethylpropane.

Check Your Solution
The three carbon atoms are the longest chain, which agrees with the root prop-. The one carbon methyl groups are numbered to give the lowest number on the main chain, so 2,2-dimethyl is correct. All the bonds are single bonds, so the suffix is correct.

8. Identify any errors in the structure by drawing them. Rename the structure correctly.
2-ethyl-2,4,4-trimethylpentane

What Is Required?
You are to identify the errors in the name by drawing the structure and renaming it correctly.

What Is Given?
You are given an incorrectly named alkane.

Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is pent- and is therefore five carbons long. It ends in -ane, and, therefore, the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 2-ethyl-2,4,4-trimethyl-, so there is a two-carbon group and a one-carbon group off the carbon 2 of the main chain. There are two one-carbon methyl groups bonded to the carbon 4 atom of the main chain. 
Find the correct root and suffix. Name the main chain.	The longest chain is six carbons long—not five, so the root name is hex-, not pent-. The root name is hexane. 
Identify the prefix. Number and name the side groups.	There are four side groups, each one carbon long. The main chain carbon atoms are numbers so that the methyl groups would have the lowest numbers, which are two and four.
Write the name.	The full name is 2,2,4,4-tetramethylhexane.

Check Your Solution
The six carbon atoms are the longest chain, which agrees with the root hex-. The main chain is numbers so the one-carbon methyl groups have the lowest possible numbers. Therefore, 2,2,4,4-tetramethyl is correct. All the bonds are single bonds, so the suffix is correct.

9. Name the compound.

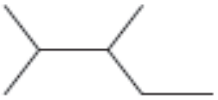
What Is Required?
You must name the compound.

What Is Given?
You are given the line structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is five carbons long as there are carbons at each change in direction and at the ends of a line. The root is pent-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	There are no side chains, so there are no prefixes.
Write the name.	The full name is pentane.

Check Your Solution
There are three direction changes in the line structural formula and two ends, so there are five carbons. There are no side branches and therefore no prefixes, so the name pentane is correct.

10. Name the compound.



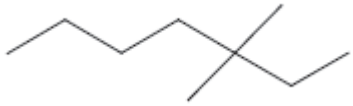
What Is Required?
You must name a compound.

What Is Given?
You are given the line structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is five carbons long as there are carbons at each change in direction and at the ends of a line. The root is pent-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	There are two one-carbon methyl groups bonded to the main chain. Numbering begins at the end that will give the side groups lowest possible numbers. The prefix is 2,3-dimethyl-.
Write the name.	The full name is 2,3-dimethylpentane.

Check Your Solution
There are three changes in direction and two ends indicating five carbons, which is correct. There are two side groups, each containing only one carbon atom so they are methyl groups. The name correctly describes the structure.

11. Name the compound.



What Is Required?
You must name the compound.

What Is Given?
You are given the line structural formula.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest chain is seven carbons long as there are carbons at each change in direction, an intersection of two lines and at the ends of a line. The root is hept-.
Find the suffix.	The compound is an alkane, so the suffix is -ane.
Find the prefix.	There are two one-carbon methyl groups bonded to the main chain. Numbering begins at the end that will give the lowest possible numbers. The prefix is 3,3-dimethyl-.
Write the name.	The full name is 3,3-dimethylheptane.

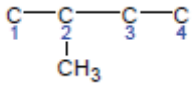
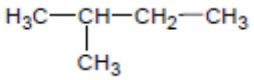
Check Your Solution
There are four direction changes, one intersection and two ends so there are seven carbons in the main chain. There are two methyl groups bonded to the third carbon. The name 3,3-dimethylheptane is correct.

Drawing an Alkane
(Student textbook page 21)

12. Draw the condensed formula for this structure: 2-methylbutane

What Is Required?
You must draw the condensed structural formula for an alkane.

What Is Given?
You are given the name of the alkane.

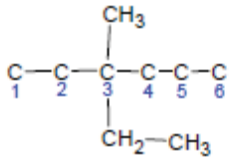
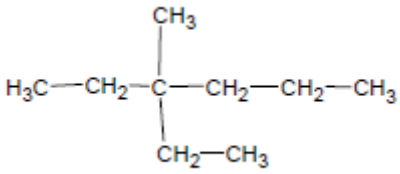
Plan Your Strategy	Act on Your Strategy
Identify the root.	The root is but-, which indicates that there are four carbons in the main chain.
Identify the suffix.	The suffix is -ane, so the molecule is an alkane. There are only single bonds between carbon atoms.
Identify the prefix, and draw the side groups.	The prefix is 2-methyl-, which indicates that there is a one-carbon methyl group on carbon atom 2. 
Complete the condensed structural formula. Add enough hydrogen atoms to each carbon atom so that each has a total of four bonds.	

Check Your Solution
The four-carbon main chain agrees with the root but-. The one-carbon group attached to carbon 2 of the main chain agrees with the prefix 2-methyl-. All bonds are single bonds.

13. Draw the condensed formula for this structure: 3-ethyl-3-methylhexane

What Is Required?
You must draw the condensed structural formula for an alkane.

What Is Given?
You are given the name of the alkane.

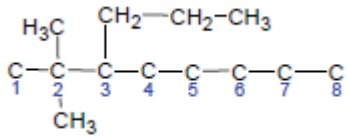
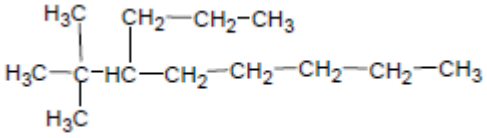
Plan Your Strategy	Act on Your Strategy
Identify the root.	The root is hex-, which indicates that there are six carbon atoms in the main chain.
Identify the suffix.	The suffix is -ane, so the molecule is an alkane. There are only single bonds between carbon atoms.
Identify the prefix, and draw the side groups.	The prefix is 3-ethyl-3-methyl-, which indicates that there is a two-carbon ethyl group on carbon atom 3 and a one-carbon methyl group on carbon atom 3. 
Complete the condensed structural formula. Add enough hydrogen atoms to each carbon atom so that each has a total of four bonds.	

Check Your Solution
The six-carbon main chain agrees with the root hex-. The two-carbon group and the one-carbon group attached to carbon 3 of the main chain agrees with the prefix 3-ethyl-3methyl-. All bonds are single bonds.

14. Draw the condensed formula for this structure: 2,2-dimethyl-3-propyloctane
Note: This molecule should be named 4-tert-butylnonane.

What Is Required?
You must draw the condensed structural formula for an alkane.

What Is Given?
You are given the name of the alkane.

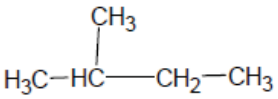
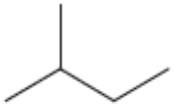
Plan Your Strategy	Act on Your Strategy
Identify the root.	The root is oct-, which indicates that there are eight carbons in the main chain.
Identify the suffix.	The suffix is -ane, so the molecule is an alkane. There are only single bonds between carbon atoms.
Identify the prefix, and draw the side groups.	The prefix is 2,2-dimethyl-3-propyl-, which indicates that there are two methyl groups on carbon atom 2 and a three-carbon propyl group on carbon atom 3. 
Complete the condensed structural formula. Add enough hydrogen atoms to each carbon atom so that each has a total of four bonds.	

Check Your Solution
The eight-carbon main chain agrees with the root hex-, however the longest chain is nine carbons long and should be non-. The two carbon group and the one-carbon group attached to carbon 3 of the main chain agree with the prefix 3-ethyl-3-methyl-. However, if the nine-carbon group is the main chain, the prefix tertiary-butyl would be the appropriate prefix. All bonds are single bonds.

15. For each of the molecules in questions 12-14, draw a line structural formula.

What Is Required?
You are to draw a line structural formula for 2-methylbutane.

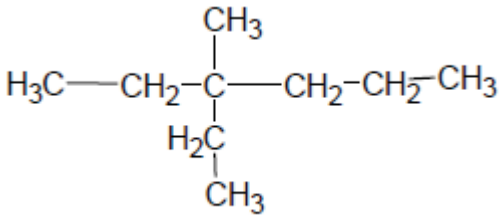
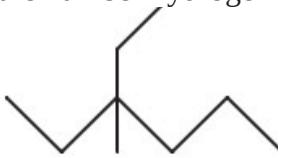
What Is Given?
You are given the name of the alkane.

Plan Your Strategy	Act on Your Strategy
Use the condensed structural formulas from question 12 to draw the line structural formulas.	Use the condensed structural formula as a guide.  Each end of a straight line represents a carbon atom, unless otherwise specified. Hydrogen atoms are not included as it is assumed each carbon atom is bonded to as many hydrogen atoms as to give it four bonds. 

Check Your Solution
The four-carbon longest chain agrees with the term but-. The one-carbon methyl group attached to the carbon 2 atom agrees with the prefix 2-methyl-. All bonds are single bonds.

What Is Required?
You are to draw a line structural formula for 3-ethyl-3-methylhexane.

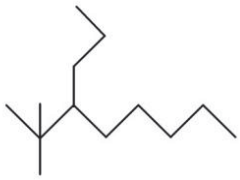
What Is Given?
You are given the name of the alkane.

Plan Your Strategy	Act on Your Strategy
Use the condensed structural formulas from question 13 to draw the line structural formulas.	Use the condensed structural formula as a guide.  Each bend, intersection, and end of a straight line represents a carbon atom, unless otherwise specified. Hydrogen atoms are not included as it is assumed each carbon atom is bonded to the number hydrogen atoms necessary to give it four bonds. 

Check Your Solution
The six-carbon longest chain agrees with the term hex-. The two-carbon ethyl group and the one-carbon methyl- group attached to the carbon 3 atom agrees with the prefix 3-ethyl-3-methyl-. All bonds are single bonds.

What Is Required?
You are to draw a line structural formula for 2,2-dimethyl-3-propyloctane.
Note: This molecule should be named 4-tert-butylnonane or 4-(1,1-dimethylethyl)nonane.

What Is Given?
You are given the name of the alkane.

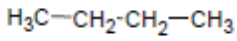
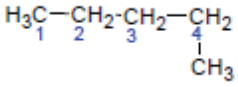
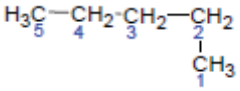
Plan Your Strategy	Act on Your Strategy
Use the condensed structural formulas from question 14 to draw the line structural formulas.	Use the condensed structural formula as a guide. $CH_3-C(CH_3)_2-CH(CH_2CH_2CH_2CH_2CH_3)-CH_2-CH_2-CH_2-CH_2-CH_3$ Each bend, intersection, and end of a straight line represents a carbon atom, unless otherwise specified. Hydrogen atoms are not included as it is assumed each carbon atom is bonded to the number hydrogen atoms necessary to give it four bonds. 

Check Your Solution
The eight-carbon main chain agrees with the root hex-, however, the longest chain is nine carbons long and should be non-. The two-carbon group and the one-carbon group attached to carbon 3 of the main chain agrees with the prefix 3-ethyl-3-methyl-. However, if the nine-carbon group is the main chain, the prefix tertiary-butyl- would be the appropriate prefix. All bonds are single bonds.

16. The name of this structure is incorrect. Draw the structure that the name describes. Rename the structure correctly.
4-methylbutane

What Is Required?
You are to identify the errors in the name by drawing the structure and then renaming it correctly.

What Is Given?
You are given an incorrectly named alkane.

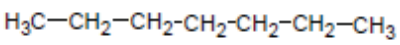
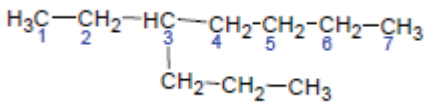
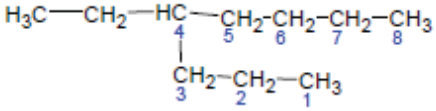
Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is but- and is therefore four carbons long. It ends in -ane, and, therefore, the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 4-methyl-, so there is a one-carbon group bonded to carbon 4 of the main. 
Find the correct root and suffix. Name the main chain.	The longest chain is five carbons long—not four, so the root name is pent-, not but-. The root name is pentane. 
Identify the prefix. Number and name the side groups.	There are no side groups, so there are no prefixes.
Write the name.	The full name is pentane.

Check Your Solution
The five carbon atoms are the longest chain, which agrees with the root pent-. There are no side chains off the longest chain, so there is no prefix. All the bonds are single bonds so the suffix is correct.

17. The name of this structure is incorrect. Draw the structure that the name describes. Rename the structure correctly.
3-propylheptane

What Is Required?
You are to identify the errors in the name by drawing the structure and then renaming it correctly.

What Is Given?
You are given an incorrectly named alkane.

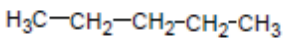
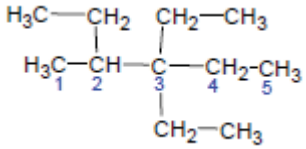
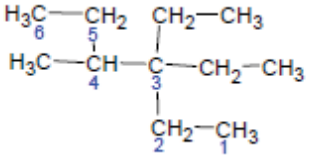
Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is hept- and is therefore seven carbons long. It ends in -ane, and, therefore, the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 3-propyl-, so there is a three-carbon group bonded to carbon 3 of the main chain. 
Find the correct root and suffix. Name the main chain.	The longest chain is eight carbons long—not seven, so the root name is oct-, not hept-. The root name is octane. 
Identify the prefix. Number and name the side groups.	There is one side group that is two carbons long. The main chain carbon atoms must start at the end nearest this two-carbon, or ethyl, side group. This numbering places the ethyl on carbon atom number 4.
Write the name.	The full name is 4-ethyloctane.

Check Your Solution
The eight carbon atoms are the longest chain, which agrees with the root oct-. The main chain in numbered starting at the end nearest the ethyl group, so 4-ethyl- is the correct prefix. All the bonds are single bonds, so the suffix is correct.

18. The name of this structure is incorrect. Draw the structure that the name describes. Rename the structure correctly.
2,3,3 triethylpentane

What Is Required?
You are to identify the errors in the name by drawing the structure then and renaming it correctly.

What Is Given?
You are given an incorrectly named alkane.

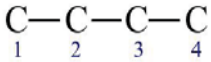
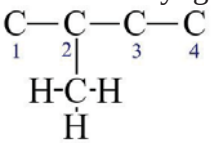
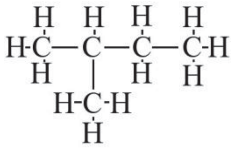
Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is pent- and is therefore five carbons long. It ends in -ane, and, therefore, the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 2,3,3-triethyl-, so there is one two-carbon ethyl group bonded to carbon 2 and there are two ethyl groups bonded to the third carbon of the main chain. 
Find the correct root and suffix. Name the main chain.	The longest chain is six carbons long—not five, so the root name is hex- not pent-. The root name is hexane. 
Identify the prefix. Number and name the side groups.	There are two side groups that are two carbons long and one side group that is one carbon long. The main chain must be numbered so that the sum of the numbers in the prefix is as low as possible. This places the ethyl groups on carbon atom three and the methyl group on carbon atom four.
Write the name.	The full name is 3,3-diethyl-4-methylhexane.

Check Your Solution
The longest chain has six carbon atoms, which agrees with the root hex-. The main chain is numbered to give the lowest sum of the numbers in the prefix, so 3,3-ethyl is correct. The one-carbon methyl group is 4- methyl-. All the bonds are single bonds, so the suffix is correct.

19. Draw the complete structural formula for the following molecule:
2-methylbutane

What Is Required?
You must draw the complete structural formula for a molecule.

What Is Given?
You are given the name of the molecule.

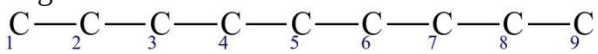
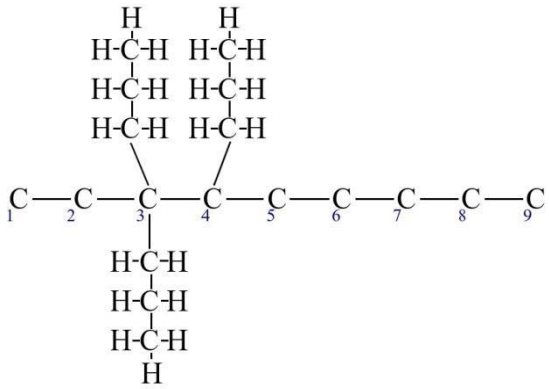
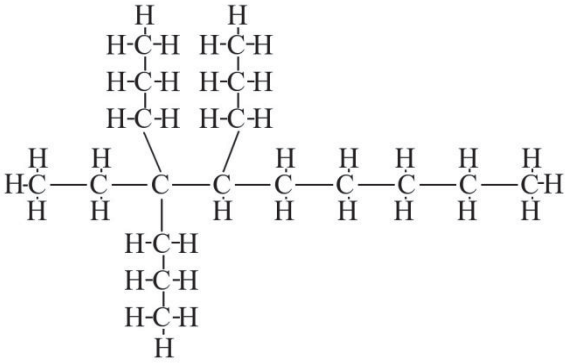
Plan Your Strategy	Act on Your Strategy
Identify the root.	The root is but-, which indicates that there are four carbons in the main chain.
Identify the suffix.	The suffix is -ane, so the molecule is an alkane. There are only single bonds between carbon atoms. 
Identify the prefix, and draw the side groups.	The prefix is 2-methyl-, which indicates that there is a one-carbon methyl group on carbon atom 2. 
Complete the condensed structural formula. Add enough hydrogen atoms to each carbon atom so that each has a total of four bonds.	

Check Your Solution
All atoms are shown, which makes the structure complete. The four-carbon main chain agrees with the root but-. The one-carbon group attached to carbon 2 of the main chain agrees with the prefix 2-methyl-. All bonds are single bonds.

20. Draw the complete structural formula for the following molecule:
3,3,4-triethylnonane

What Is Required?
You must draw the complete structural formula for a molecule.

What Is Given?
You are given the name of the molecule.

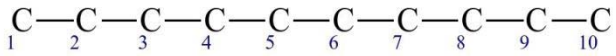
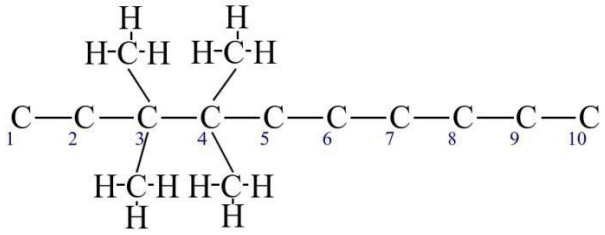
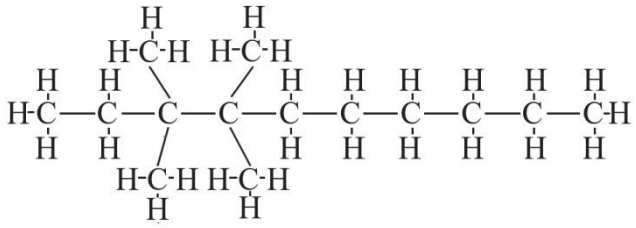
Plan Your Strategy	Act on Your Strategy
Identify the root.	The root is non-, which indicates that there are nine carbons in the main chain.
Identify the suffix.	The suffix is -ane, so the molecule is an alkane. There are only single bonds between carbon atoms. 
Identify the prefix, and draw the side groups.	The prefix is 3,3,4-triethyl-, which indicates that there are three two-carbon ethyl groups on carbons 3, 3, and 4. 
Complete the condensed structural formula. Add enough hydrogen atoms to each carbon atom so that each has a total of four bonds.	

Check Your Solution
All atoms are shown, which makes the structure complete. The nine-carbon main chain agrees with the root non-. The two-carbon groups attached to carbon 3, 3, and 4 of the main chain agrees with the prefix 3,3,4-triethyl-. All bonds are single bonds.

21. Draw the complete structural formula for the following molecule:
3,3,4,4-tetramethyldecane

What Is Required?
You must draw the complete structural formula for a molecule.

What Is Given?
You are given the name of the molecule.

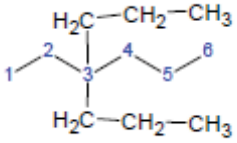
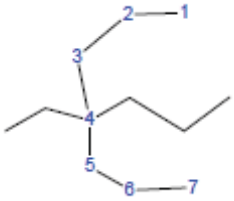
Plan Your Strategy	Act on Your Strategy
Identify the root.	The root is dec-, which indicates that there are ten carbons in the main chain.
Identify the suffix.	The suffix is -ane, so the molecule is an alkane. There are only single bonds between carbon atoms. 
Identify the prefix, and draw the side groups.	The prefix is 3,3,4,4-tetramethyl-, which indicates that there are four 1-carbon methyl groups, two on carbon atom 3 and two on carbon atom 4. 
Complete the condensed structural formula. Add enough hydrogen atoms to each carbon atom so that each has a total of four bonds.	

Check Your Solution
All atoms are shown, which makes the structure complete. The ten-carbon main chain agrees with the root dec-. The 4 one-carbon groups attached to carbon 3 and 4 of the main chain agree with the prefix 3,3,4,4-tetramethyl-. All bonds are single bonds.

22. Draw the line structure for the incorrectly named molecule 3,3 dipropyl hexane. Name it correctly.

What Is Required?
You are to identify the errors in the name by drawing the line structural formula and renaming it correctly.

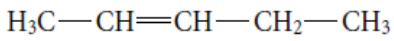
What Is Given?
You are given an incorrectly named alkane.

Plan Your Strategy	Act on Your Strategy
Draw the root.	The root in the incorrect name is hex-, which indicates six carbons. It ends in -ane, and, therefore, the structure has only single bonds. 
Use the prefix to identify and draw the side groups.	The prefix is 3,3-dipropyl-, so there are two three-carbon propyl groups bonded to carbon three of the main chain. 
Find the correct root and suffix. Name the main chain.	The longest chain is seven carbons long—not six, so the root name is hept-, not hex-. The root name is heptane. 
Identify the prefix. Number and name the side groups.	There are two side groups. The ethyl and propyl groups would be numbered to give them the lowest number, which is four regardless of which end is numbered one. The prefix is ordered alphabetically disregarding multiplying prefixes.
Write the name.	The full name is 4-ethyl-4-propylheptane.

Check Your Solution
The seven-carbon main chain agrees with the root hept-. The three-carbon group and the two-carbon groups attached to carbon 4 atom agree with the prefix 4-ethyl-4-propyl-. All bonds are single bonds.

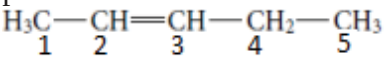
Naming Alkenes
(Student textbook page 26)

23. Name the following alkene.



What Is Required?
You must name the alkene.

What Is Given?
You are given the structural formula of the alkene.

Plan Your Strategy	Act on Your Strategy
Find the root.	The longest carbon chain has 5 carbons. The root is pent-.
Determine the suffix.	Assign numbers to the carbon chain from left to right so that the first carbon involved in the double bond has the lowest possible number.  Because the molecule has one double bond between carbon 2 and 3, the suffix is -2-ene.
Write the name.	pent-2-ene

Check Your Solution
The length of the main chain and the position of the double bond agree with the given structure.