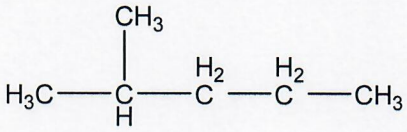
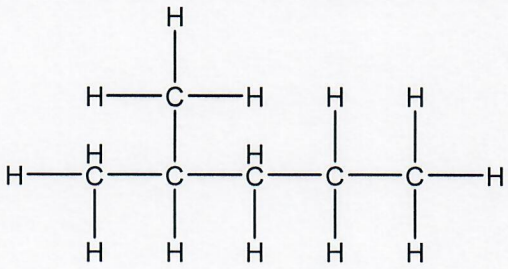
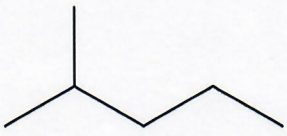
- **Organic chemistry** is the study of hydrocarbons, which are compounds that consist of carbon and hydrogen atoms. These compounds are essential to our modern society as they are used as fuels for transportation and heating and as raw materials for plastics and synthetic fabrics.
- **Many carbon containing compounds are not organic:**
  - Oxides of carbon and carbonates are **not** organic. E.g. CO, CO_2 , CO_3^{2-}, HCO_3^{1-}
  - ionic compounds that contain carbon
  - carbon-sulphides (e.g. CS_2) and carbon-nitrides (e.g. HCN)
- There are two major classes of hydrocarbons:
  - **Aliphatic hydrocarbons** do not contain a benzene ring.
  - **Aromatic hydrocarbons** contain a benzene ring (benzene ring described later).
- In organic chemistry, there are 5 different ways to represent the structure of an organic compound:

Style	Example	Info about style
Molecular formula	C_6H_{14}	• Shows only basic information of number and types of atoms present. • Not useful.
Expanded molecular formula	$CH_3CH(CH_3)CH_2CH_2CH_3$	• Shows groupings of atoms. • Brackets used to indicate locations of branch chains.
Condensed structural formula		• Carbon-hydrogen bonds not shown to save space; all other bonds shown. • Shows structure
Structural formula		• Gives clear picture of all atoms and locations of bonds. • All covalent bonds shown. • Excellent detail; requires lots of space
Line structural formula		• Lines used to represent bonds. • The end of a line & the "elbows" in lines indicate a carbon atom. • Each carbon assumed to have enough hydrogens bonded to it to give it four bonds. • Symbols of atoms other than carbon & hydrogen are written in the structure. • Easiest & most commonly used in organic chemistry.

© 2012 T. de Bruin

Alkanes

- The simplest hydrocarbons, consisting of carbon atoms covalently bonded with only single bonds.
- Non-polar and thus London force is the only intermolecular force acting among them.
- Alkanes are called **saturated hydrocarbons** since each carbon atom is bonded to as many other atoms as possible.
- The longest continuous chain of carbons within a hydrocarbon is called the **parent chain**.
- Parent chain names are composed of two parts, the **root** (number of carbon atoms) and the **suffix** (the series the molecule belongs to).
    - The suffix name for alkanes is **–ane,** which indicates single bonded parent carbons.
    - Root names are specific to the number of carbon atoms in the parent chain. The following root name list must be memorized as it forms the base for the entire organic nomenclature (naming system).

Number of carbon atoms	Root	Alkane molecule	Alkane formula	Useage example
1	**meth**	methane	CH_4	"natural gas"/home heating
2	**eth**	ethane	C_2H_6	Plastics raw material
3	**prop**	propane	C_3H_8	Bar-be-que fuel
4	**but**	butane	C_4H_{10}	Camping stove fuel
5	**pent**	pentane	C_5H_{12}	Gasoline component/solvent
6	**hex**	hexane	C_6H_{14}	Gasoline component/solvent
7	**hept**	heptane	C_7H_{16}	Gasoline component/solvent
8	**oct**	octane	C_8H_{18}	Gasoline component/solvent
9	**non**	nonane	C_9H_{20}	Gasoline component/solvent
10	**dec**	decane	$C_{10}H_{22}$	Gasoline component/solvent

- The **general formula for an alkane is C_nH_{2n+2}** (even when branches off the parent chain are present.)
- Any set of molecules that differ by one specific unit, such as $-CH_2-$, is called a **homologous series**. The alkanes listed in the table above are a homologous series.
- Alkane parent chains can have branches (also called side groups or side chains) of carbon atoms attached to them. Branch carbons are named using the root for the number of carbons present, but use the suffix **–yl** to indicate that they are not part of the parent chain. Carbon branches based on alkanes are called **alkyl groups**.
    - Example:

methyl	ethyl	propyl	butyl
$-CH_3$	$-CH_2CH_3$	$-CH_2CH_2CH_3$	$-CH_2CH_2CH_2CH_3$

- Carbon branches are listed as a prefix to the parent chain name, giving **both name and position** on the parent chain where they are attached.
- On long parent chains, branches may be located in several different locations on the molecule. Thus parent chains are numbered either from left-to-right or right-to-left so that any branches present have a location number that is the lowest possible. Think of the numbers like a house address.
- Once a parent chain has been numbered, the numbers cannot be changed.

© 2012 T. de Bruin

- **Rules for naming side groups**:
  1. All branches are named before the parent chain
  2. A carbon branch prefix starts with its location number, followed by a hyphen, and then the alkyl name.
     - Example a methyl group on parent carbon 2 is listed as "2-methyl"
  3. If there is more than one side group, they are listed alphabetically.
  4. If there is more than one of the same carbon branch, the locations numbers are separated by a comma, followed by a hyphen then the appropriate prefix to indicate the number of identical branches and then the alkyl group name.

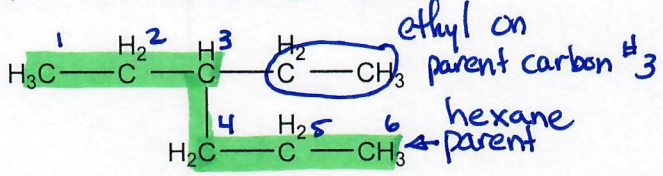
Amount	Prefix
2	di
3	tri
4	tetra
5	penta
6	hexa

Amount	Prefix
7	hepta
8	octa
9	nona
10	deca

     - Example: if there are two methyl branches, one on carbon #2 and one on carbon #5, the branch prefix would be: "2,5-dimethyl"
  5. When determining alphabetical order, ignore the amount prefixes di, tri tetra etc.
     - Example: dipropyl is listed after methyl
- In hydrocarbon names all numbers are separated from other numbers by commas and words are separated from numbers by hyphens. There are no spaces inbetween names.
- **Steps in naming alkanes**:
  1. **Identify the parent chain** (root+ane suffix)
     - Find the longest continuous chain of carbons without backtracking. Using a highlighter will help.
     - Carbon chains can bend and twist.
  2. **Identify carbon branches**
     - Identify the number of carbons in each branch and its alkyl name.
     - Number the parent chain so that the branches have the lowest possible location numbers.
     - Preceed each branch with its location number.
     - List the branches alphabetically.

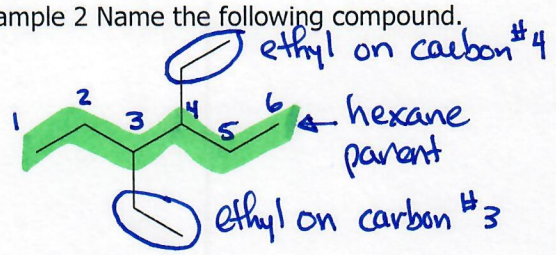
© 2012 T. de Bruin

- Example 1 Name the following compound.



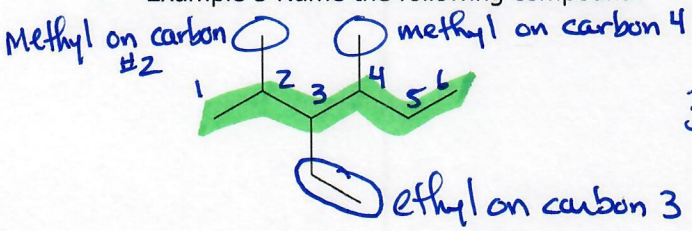
3-ethylhexane

- Example 2 Name the following compound.



3,4-diethylhexane

- Example 3 Name the following compound.



3-ethyl-2,4-dimethylhexane

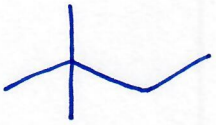
- **Steps in drawing alkanes.**
  1. Identify the parent chain name (root+suffix)
     - The root identifies the number of parent carbons present
     - The suffix (-ane) tells you there are only single bonds present.
  2. Draw the parent chain first using the either the structural diagram style or the line diagram style.
  3. Choose one end of your parent chain to be carbon number one.
  4. Add the branch(es) at the appropriate location(s) on the parent chain. Branches can be added to either side of the parent chain.
  5. If using the structural diagram, add enough hydrogen atoms to give each carbon 4 bonds.
- Example 1: draw the structural diagram to represent 3-ethylpentane

carbon branch — parent chain.

© 2012 T. de Bruin

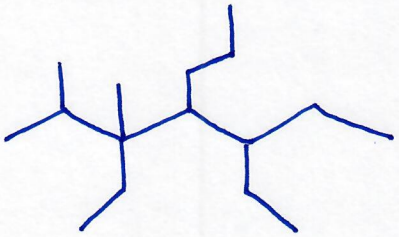
- Example 2: draw the line structural diagram for 2,2-dimethylbutane

4 carbon parent.



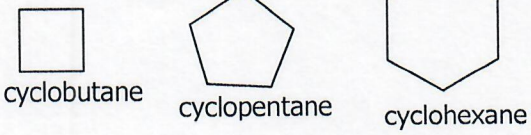
- Example 3: draw the line structural diagram to represent 3,5-diethyl-2,3-dimethyl-4-propylheptane

7 carbon parent.



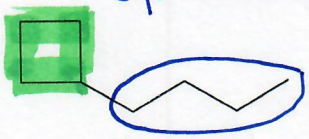
- alkanes can connect their parent chain ends together to form ring-like structures called ***cycloalkanes***.
- In a cycloalkane, the ring structure is automatically the parent.
- Cycloalkane parent names are based on the alkane parent name (root+suffix) but have the prefix ***cyclo***.

1. Examples:



- If there is only one side chain, it is automatically on parent carbon #1 and thus it does not need its location number in the chemical name.
- If more than one side group is present, the cyclo parent carbons are numbered starting with any of the side groups and goes in the direction to make the numbers of any other side groups as low as possible.
- Example 1. Name the following compound.

cyclobutane parent.

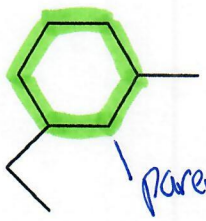


butyl branch.

butylcyclobutane

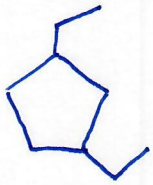
© 2012 T. de Bruin

- Example 2. Name the following compound.



1-ethyl-3-methylcyclohexane
-or-
3-ethyl-1-methylcyclohexane

- Example 3. Draw a line structural diagram to represent 1,3-diethylcyclopentane



draw parent first, then pick any parent carbon to be carbon #1

Complete the following practice problems in your textbook:

- p. 549 #1-3; p. 550 #4-9

Practice Problems

1. Provide names for the following molecules:

a) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_3$

b) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-CH_3$

c) $CH_3-\underset{\displaystyle CH_2}{\underset{|}{CH}}-CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\overset{\displaystyle CH_2-CH_3}{\overset{|}{CH}}-CH_3$

d) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-CH_2-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-CH_2-CH_3$

e) $CH_3-CH_2-CH_2-\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle CH_2}{\underset{|}{C}}}}-CH-\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle CH_3}{\underset{|}{C}}}}-CH_3$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad CH_2$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad CH_3$

2. Identify any errors in the name of each of the following hydrocarbons. (**Hint:** Where possible, draw the structures as named. Then examine the structures and rename them.)

a) 2,2,3-dimethylbutane

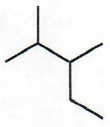
b) 2,4-diethyloctane

c) 3-methyl-4,5-diethylnonane

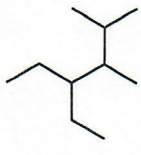
3. Name each of the following compounds:

a)

b)



c)



© 2012 T. de Bruin

Practice Problems

4. Draw a structural formula for each of the following organic molecules:

a) propane

b) 2-methylbutane

5. Draw a condensed structural formula for each of the following:

a) 2,4,6- trimethyloctane

b) 4-ethyl-3-methylheptane

6. For each of the molecules listed in question 5, draw an expanded molecular formula.

7. The following names are incorrect. Draw structures that these names describe. Examine your drawing, and rename the hydrocarbon correctly.

a) 3-propylbutane

b) 1,3-dimethylhexane

c) 4-methylpentane

8. Draw a line structural formula for each of the following alkanes:

a) 3-ethyl-3,4-dimethyloctane

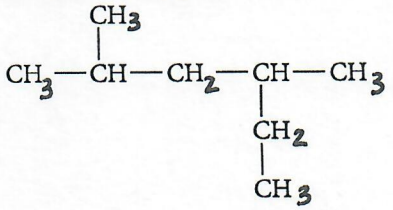
b) 2,3,4-trimethylhexane

c) 4-ethyl-3,3-dimethylheptane

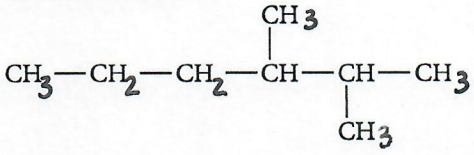
d) 4,6-diethyl-2,5-dimethylnonane

9. Examine the following compounds and their names. Identify any mistakes, and correct the names as necessary.

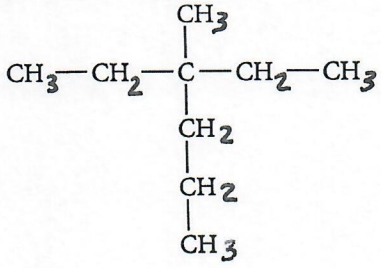
a) 4-ethyl-2-methylpentane



b) 4,5-methylhexane



c) 3-methyl-3-ethylpentane



CHEMISTRY 30 - ANSWERS TO TEXTBOOK ALKANE PROBLEMS.

Answers to Practice Problems 1–3

For full solutions to the practice problems, visit **www.albertachemistry.ca**, Online Learning Centre, Instructor Edition, Full Solutions.

Student Textbook page 549

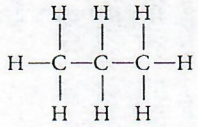
1. **(a)** 2-methylbutane
   (b) 2,2-dimethylpropane
   (c) 3-ethyl-2,5-dimethylheptane
   (d) 2,2,4,4-tetramethylhexane
   (e) 2,2,4-trimethyl-4-propylheptane
2. **(a)** 2,2,3-trimethylbutane
   (b) 5-ethyl-3-methylnonane
   (c) 4,5-diethyl-3-methylnonane
3. **(a)** heptane
   (b) 2,3-dimethylpentane
   (c) 4-ethyl-2,3-dimethylhexane

Answers to Practice Problems 4–9

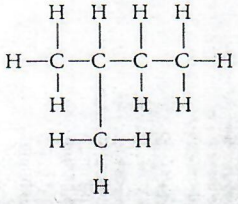
For full solutions to the practice problems, visit **www.albertachemistry.ca**, Online Learning Centre, Instructor Edition, Full Solutions.

Student Textbook page 550–551

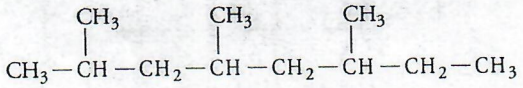
4. **(a)**



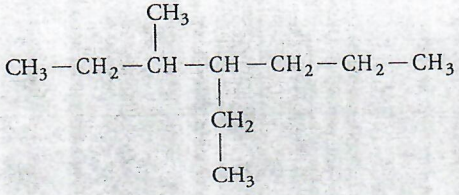
(b)



5. **(a)**

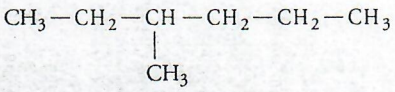


(b)

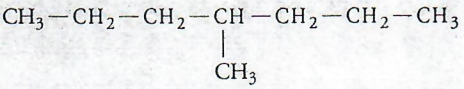


6.
   (a) $CH_3CH(CH_3)CH_2CH(CH_3)CH_2CH(CH_3)CH_2CH_3$
   (b) $CH_3CH_2CH(CH_3)CH(C_2H_5)CH_2CH_2CH_3$

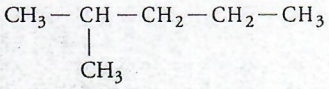
7.
   (a)



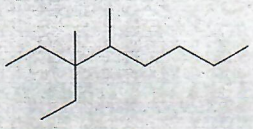
   (b)



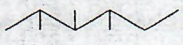
   (c)



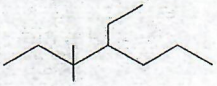
8.
   (a)



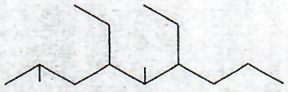
   (b)



   (c)



   (d)



9. **(a)** The longest continuous chain has 6 carbons, not 5, with two methyl groups (CH_3^-) on carbons C_2 and C_4. The correct name is 2,4-dimethylhexane.
   (b) The longest continuous chain of 6 carbons should be numbered from right to left. The correct name is 2,3-dimethylhexane.
   (c) The longest continuous chain has 6 carbons, not 5, with an ethyl group ($C_2H_5^-$) and a methyl group (CH_3^-) on carbon C_3. The correct name is 3-ethyl-3-methylhexane.