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# Section 2: Alkanes

Q: What is the basic structural characteristic of alkanes?

(Contains single bonds between carbon atoms)

Q: What is the difference between saturated hydrocarbon and unsaturated hydrocarbon?

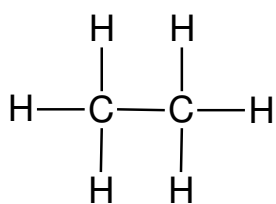
## Hydrocarbons

Saturated

have a **greater number of hydrogen atoms** linked by single covalent bonds to carbon atoms

single bond between all carbon atoms

Alkanes

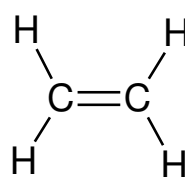


Unsaturated

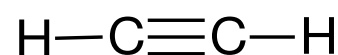
have **fewer hydrogen atoms**, because there are not four single covalent bonds for all carbon atoms

Multiple bond between all carbon atoms

Alkenes



Alkynes



general  
formula

**Alkanes** : Hydrocarbons that contain single covalent bonds between carbon atoms.

Examples of the most commonly used alkanes: natural gas (methane - ethane - propane - butane)

60-90%

0-20%

Note: Benzene flame = (natural gas + propane)

# Alkanes

01 straight-chain

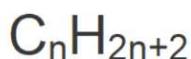
02 branched-chain

03 cyclic

## 1 Straight chain

General formula

In it, the carbon atoms are connected by one continuous line



Q1: What is the molecular formula of saturated hydrocarbon (alkane) containing 13 carbon atoms?

Q2: What is the basic structural characteristic of alkanes?

Note: The ancient Greek or Latin names represent the number of carbon atoms in the chain

### Prefix of Carbon atom chain

Number of carbon atom	Prefix
1	Meth
2	Eth
3	Prop
4	but
5	Pent
6	Hex
7	Hept
8	Oct
9	Non
10	Dec

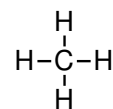
<b>Alkane</b> Molecular formula ( $C_nH_{2n+2}$ )	<b>Structural formula</b>	<b>Condensed formula</b>
<b>methane</b> <b>C</b> H <sub>4</sub> (smallest alkane)	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \end{array}$	CH <sub>4</sub>
<b>ethane</b> C <sub>2</sub> H <sub>6</sub>	$\begin{array}{c} \text{H} \quad \text{H} \\   \quad   \\ \text{H}-\text{C}-\text{C}-\text{H} \\   \quad   \\ \text{H} \quad \text{H} \end{array}$	CH <sub>3</sub> - CH <sub>3</sub>
<b>C<sub>3</sub>H<sub>8</sub></b> <b>propane</b>		
<b>C<sub>4</sub>H<sub>10</sub></b> <b>butane</b>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\   \quad   \quad   \quad   \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\   \quad   \quad   \quad   \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	CH <sub>3</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>3</sub>
<b>C<sub>5</sub>H<sub>12</sub></b> <b>pentane</b>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\   \quad   \quad   \quad   \quad   \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\   \quad   \quad   \quad   \quad   \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	CH <sub>3</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>3</sub>
<b>C<sub>6</sub>H<sub>14</sub></b> <b>hexane</b>		
<b>C<sub>7</sub>H<sub>16</sub></b> <b>heptane</b>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\   \quad   \quad   \quad   \quad   \quad   \quad   \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\   \quad   \quad   \quad   \quad   \quad   \quad   \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	CH <sub>3</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>2</sub> - CH <sub>3</sub> CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>
<b>C<sub>8</sub>H<sub>18</sub></b> <b>octane</b>		
<b>C<sub>9</sub>H<sub>20</sub></b> <b>nonane</b>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	
<b>C<sub>10</sub>H<sub>22</sub></b> <b>decane</b>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \\ \text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \quad   \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	

Met  
ane  
Prefix  
suffix

The prefix underlined by a line represents the number of carbon atoms

**Example1: Methane:** CH<sub>4</sub>, the **smallest hydrocarbon:**

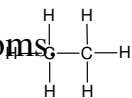
A - **Fuel** is used in homes and science laboratories



B - It results **from** many **vital processes**

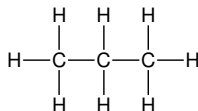
**Example2: Ethane** C<sub>2</sub>H<sub>6</sub>: consists of two carbon atoms bound together by a single covalent

bond, and six hydrogen atoms



**Example3: Propane** gas C<sub>3</sub>H<sub>8</sub>: consists of 3 carbon atoms bound together by a single covalent

bond, and 8 hydrogen atoms.



**Some uses:**

► **Propane** (Liquefied propane or LP): fuel for **cooking** and heating.

► **Butane:** fuel in **small lighter**, in some **torches**, and **manufacture of synthetic rubber**.

**Notes:**

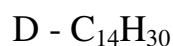
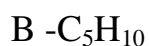
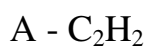
1 - The methane, ethane, propane and butane compounds were named before the knowledge of the construction of alkanes, so **the first syllables of their names are not derived from a numerical prefix.**

2 - The **pentane** is a **pentagon**

3 - **Octane** like **Octopus** or **the eight probes**.

**Choose the correct answer :**

1 - Which of the following compounds is alkane?



2 - The compound C<sub>8</sub>H<sub>18</sub> is called:

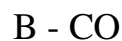
A - octene

B - octyne

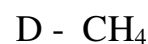
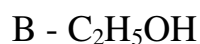
C - octane

D - propane

3 - which of the following is organic compounds:



4 - Which of the following is not organic compounds:



5 - Which of the following is not a carbon characteristic:

A - It has 4 valence electrons

B - it combines with similar or other elements

C - It creates 4 mono covalent bonds

C - cannot form chains or rings

9 - Compounds that contain only elements C and H are:

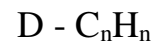
A - hydrocarbons

B - hydrocarbon derivatives

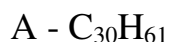
C - alcohols

D - carboxylic acids

35 - The general formula for alkanes is:



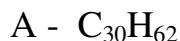
36 - Which of the following belongs to alkanes:



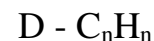
39 - The general formula for alkenes is:



40 - Which of the following alkenes:



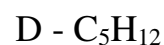
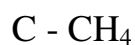
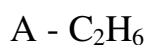
41 - The general formula for alkenes is:



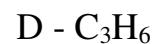
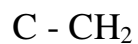
42 - Which of the following of the alkynes:



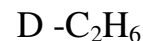
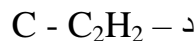
43 - Which of the following is the smallest alkane?



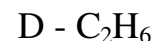
44 - Which of the following is the smallest alkene?



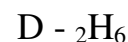
45 - Which of the following is the smallest alkyne?



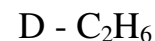
46 - Which of the following is the saturated hydrocarbon?



47 - Which of the following is unsaturated hydrocarbons?



48 - Which of the following is not considered a cycloalkane?

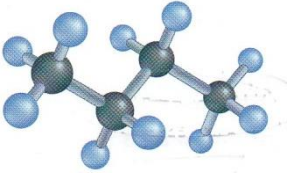
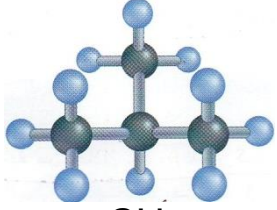
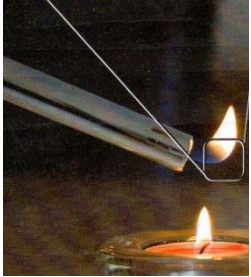
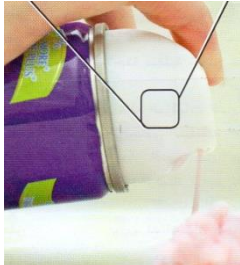


## ② Branched chain

General formula:  $C_nH_{2n+2}$ .

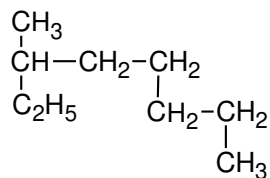
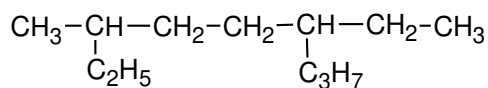
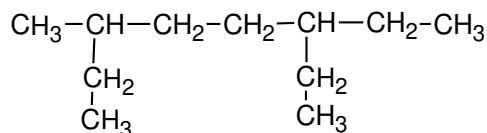
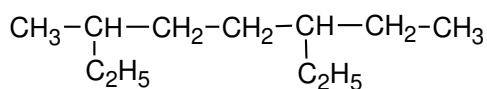
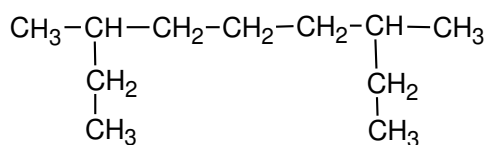
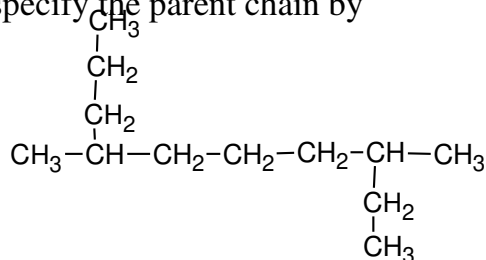
**Note:** The branched and straight alkanes have the same molecular formula.

**Discuss and compare:**

Butane	Isobutane
 <p><math>CH_3-CH_2-CH_2-CH_3</math></p>	 <p><math>CH_3-CH-CH_3</math></p>
<p>Although the structural formula for both is <math>C_4H_{10}</math>, <b>they differ in chemical and physical properties</b></p>	
<p>It is used in lighters and torches</p> 	<p>* Used in safe refrigerants. * A driving substance in similar products as shaving gel.</p> 
<p><b>Note:</b> Both <b>butane</b> and <b>isobutane</b> are used as <u>raw materials in many chemical processes.</u></p>	

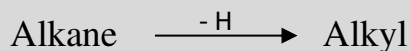
**The parent chain (main):** is the longest continuous chain of carbon atoms (continuous).

Q: specify the parent chain by



**Substituent groups (alkyl group):** are all side branches of the parent chain.

:It is the alternative group that replaces the hydrogen atom in the straight (non-branching) chain

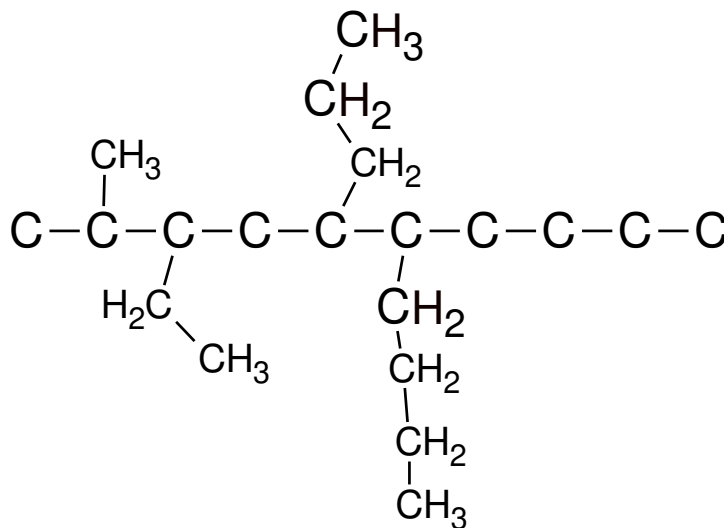


**Note:** The “substituent group of the parent chain” has the same “name of the straight-chain parent alkanes that have the same number of carbon atoms” with the substitution of the suffix “ane” with the suffix “yl”

Alkane		alkyl	
C H <sub>4</sub>	methane	m methyl	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}- \\   \\ \text{H} \end{array}$ -C H <sub>3</sub>
C <sub>2</sub> H <sub>6</sub>	ethane	-CH <sub>2</sub> -CH <sub>3</sub>	e ethyl -C <sub>2</sub> H <sub>5</sub>
C <sub>3</sub> H <sub>8</sub>	propane	-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>3</sub>	p propyl -C <sub>3</sub> H <sub>7</sub>
C <sub>4</sub> H <sub>10</sub>	butane	-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>3</sub>	b butyl -C <sub>4</sub> H <sub>9</sub>

**Nomenclature of the substituent group (the alkyl group):**

number of carbon atoms + the suffix "yl" instead of the suffix "ane" in the alkanes.





**Nomenclature of branched chain alkanes:** The chemists used the following methodological rules approved by the International Union of Pure and Applied Chemistry (IUPAC) to name organic compounds.

## International Union of Pure and Applied Chemistry

**Step 1:** Number carbon atoms in the longest continuous chain and name the alkanes.

**Step 2:** Number each carbon atom in the parent chain, starting numbering from the terminal carbon atom closest to the substituent group.

**“This step allows all substituent group sites to be given the smallest possible numbers”**

**Step 3:** Name each substituent alkyl group **and** put the group name before the parent string name.

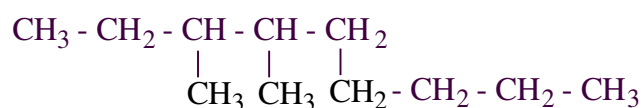
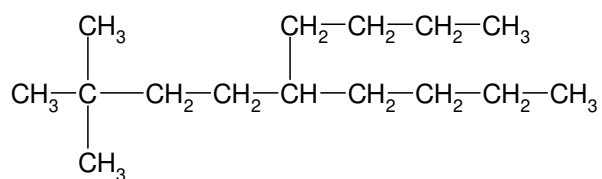
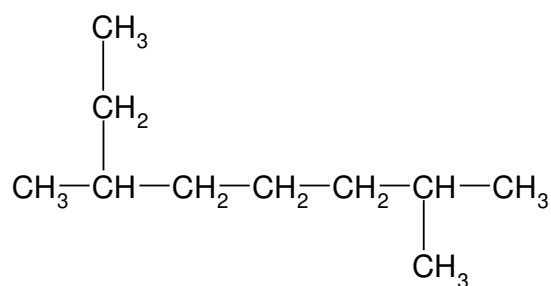
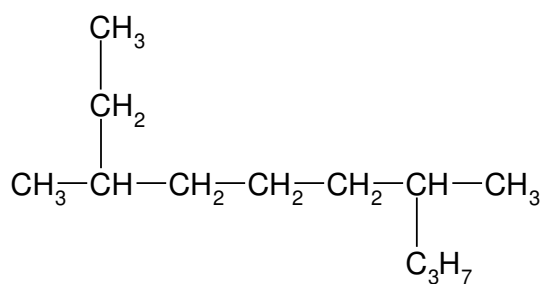
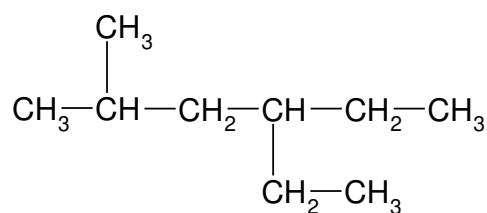
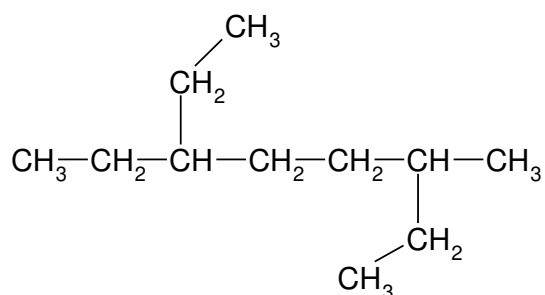
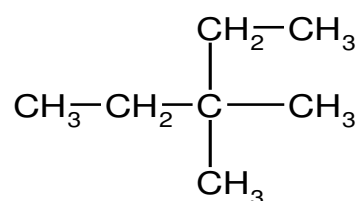
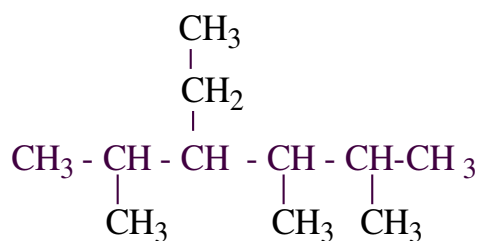
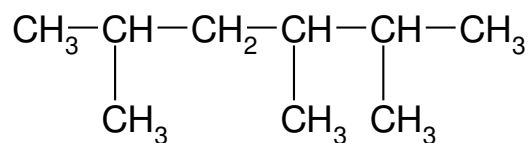
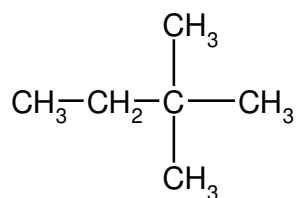
**Step 4:** If the same alkyl group is repeated more than once as a branched chain from the parent chain, use a prefix (Di-tri-Tetra ... and so on) before the name of the parent chain to indicate the number of occurrences, then use the carbon atom number to which each group is related To locate it.

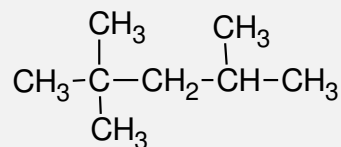
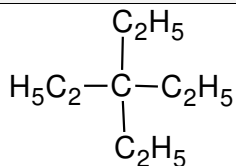
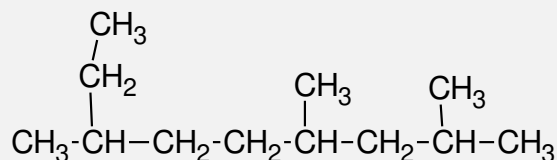
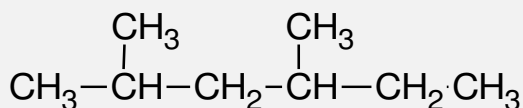
**Step 5:** When different alkyl groups are linked on similar sites of the parent chain, **alphabetical order of the English language** is used (the prefixes Di, Tri, .... not considered)

**Step 6:** Use **dashes to separate numbers from words**, **commas to separate numbers**, and leave no space between the name of the substituent (alkyl) and the name of the parent chain.

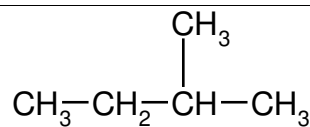
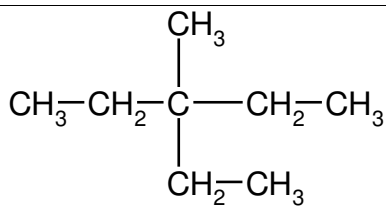
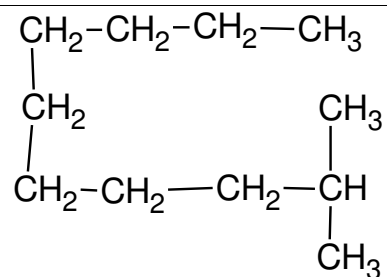
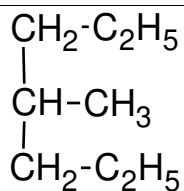
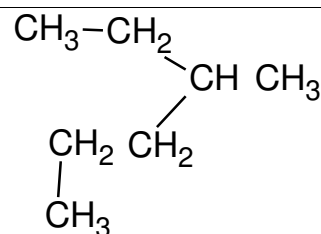
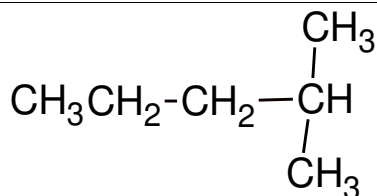
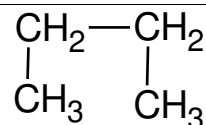
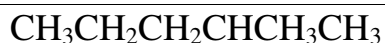
**Q:** Use IUPAC rules to name the structural formula for the following compounds:

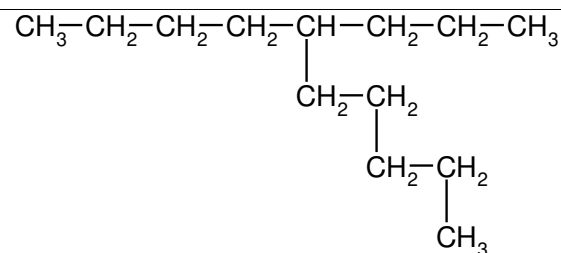
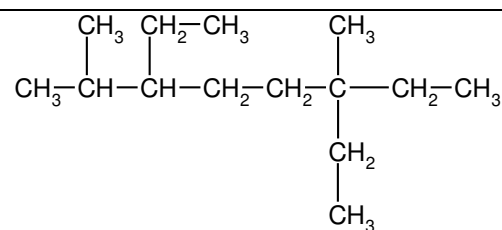
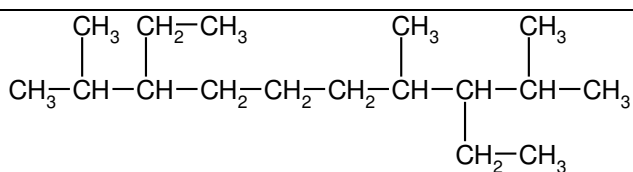
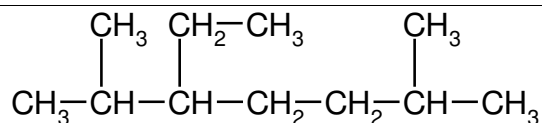
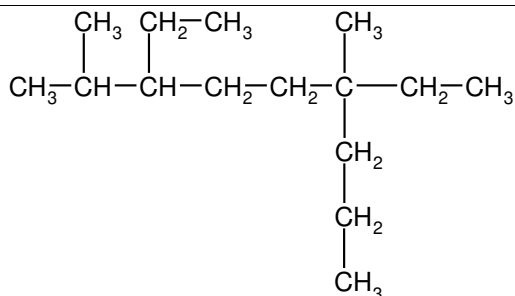
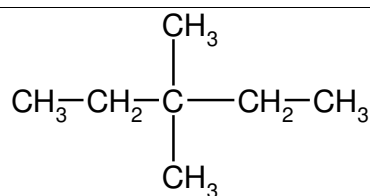
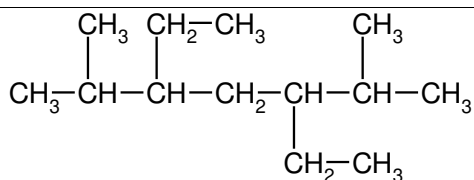
$\text{CH}_3 - (\text{CH}_2)_4 - \text{CH}_3$	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$
$\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \end{array}$
$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH} - \text{CH}_3 \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH} - \text{CH}_3$ $\quad \quad \quad   \quad  $ $\quad \quad \quad \text{CH}_3 \quad \text{CH}_3$
$\begin{array}{c} \text{CH}_3 \quad \quad \quad \text{CH}_3 \\   \quad \quad \quad   \\ \text{CH}_3 - \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	$\begin{array}{c} \text{CH}_3 \quad \quad \quad \text{CH}_3 \\   \quad \quad \quad   \\ \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \end{array}$





### Additional exercises





**Q: Draw structural formulas for the following alkanes:**

3,3 - Dimethyl - 2, 5 - Dimethyl Nonane

2, 4 - dimethyl pentane

2 - methyl propane

4- Ethyl-3-methyl heptane

4 - methyl octane

3, 3, 4 - trimethyl-4-methyl hexane

2,3 - dimethyl - 5 - propyl decane

2, 2 - dimethyl-4-propyl octane

**Isobutane**

3, 4, 5 - Triethyl Octane

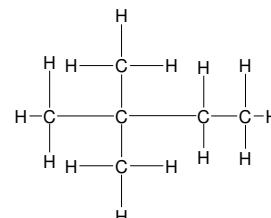
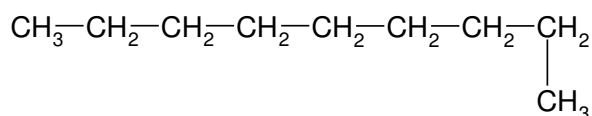
**Q1:** The correct name for the adjacent shape is:

A - 2,2 - dimethyl butane

B - 1,1,1 - trimethyl propane

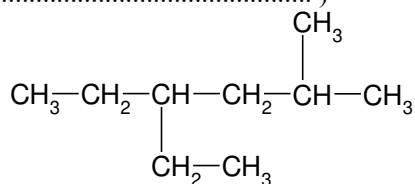
C- 2-Ethyl-2-Methyl Propane

D-3,3-Dimethyl Butane (A)

**Q2 - Determine if the naming of the alkanes is correct in each of the following, and if not, write the correct name**

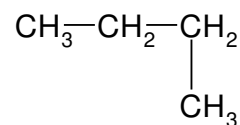
(Nonane)

(.....)



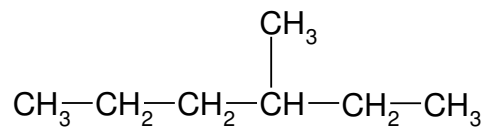
(4 - ethyl-2 - methylhexane)

(.....)



(1 - methylpropane)

(.....)



(4 - methylhexane)

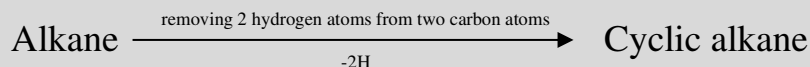
(.....)

## Cyclic Hydrocarbons

an organic compound containing a hydrocarbon ring.

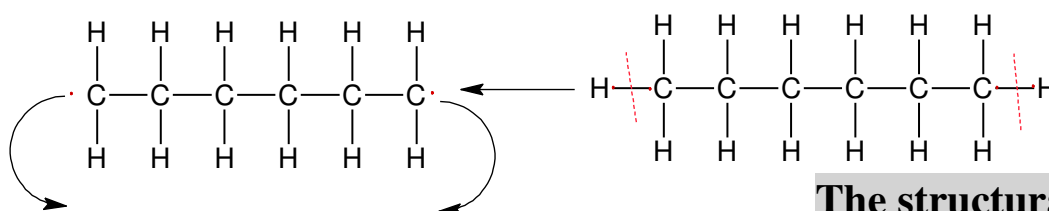
**Note:** The rings in the cyclic alkanes consist of 3, 4, 5 or 6 carbon atoms or more.

**Cyclic alkane:** Cyclic hydrocarbons contain only single bonds between carbon atoms.



**Explain:** Because one valence electron from each of the two carbon atoms in the cycloalkane forms a carbon-carbon bond instead of a carbon-hydrogen bond.

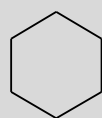
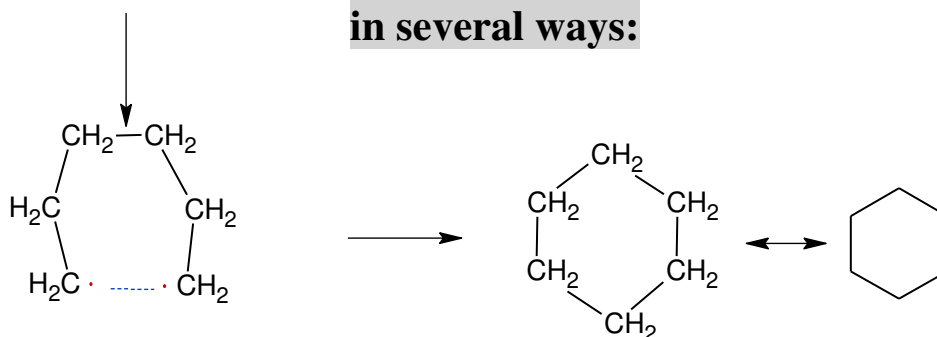
**Example:** Hexane has the molecular formula  $C_6H_{14}$ , and cyclohexane has the molecular formula  $C_6H_{12}$



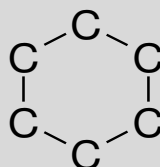
of cyclohexane

in several ways:

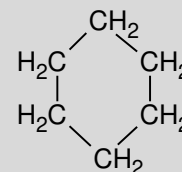
The structural formula



linear formula



Skeletal formula



Condensed structural formula

Only the bonds between carbon atoms are shown, and the angles explain the locations of carbon atoms, and the hydrogen atoms are supposed to occupy the remaining positions in the bond unless there are alternatives.

**Cyclohexane** is extracted from petroleum and is **used in:**

- 1 - Paint Solvents
- 2 - Polishing Materials
- 3 - Extract the essential oils used in perfumery


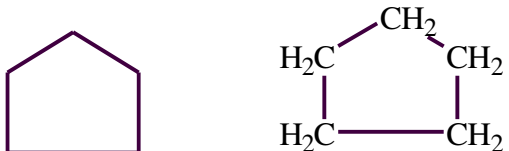
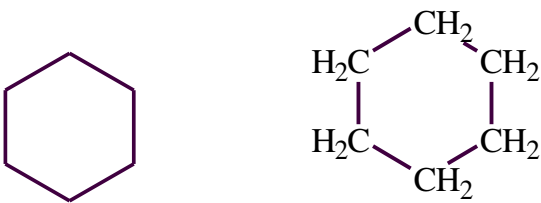
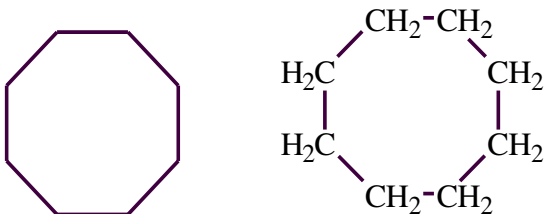
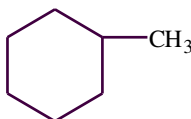
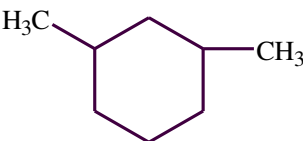
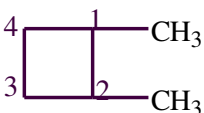
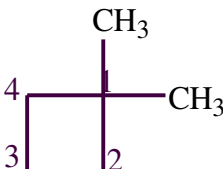
**Naming alternate cyclic alkanes:** There is no need to search for the longest carbon or chain, because the cyclic chain is endless, so the parent chain is the cycle.

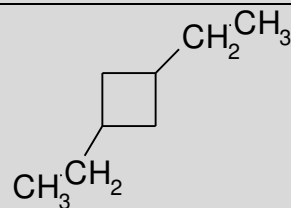
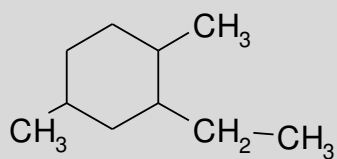
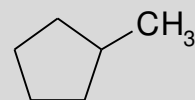
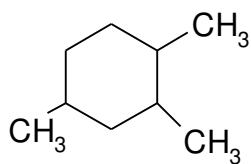
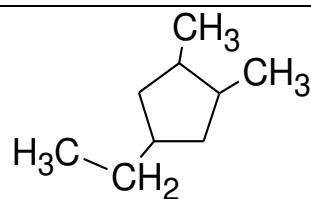
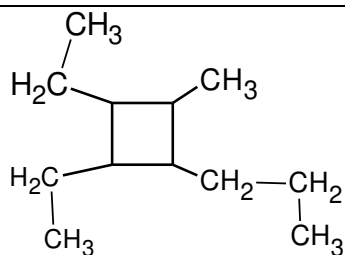
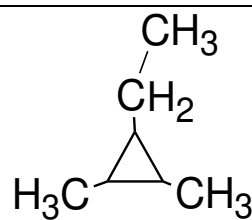
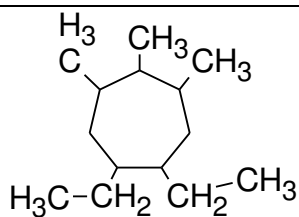
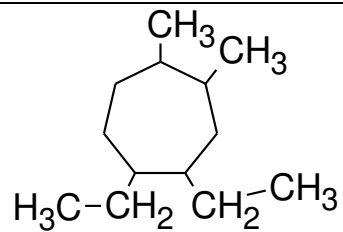
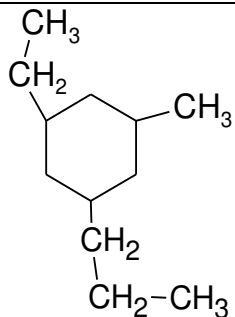
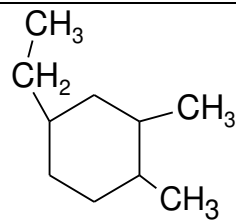
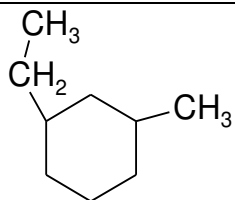
- 1 - the parent hydrocarbon = cyclo + number of cyclo carbon atoms
- 2 - Add the names of the alkyl groups.
- 3 - number of the parent carbon atoms closest to the branch, giving the smallest numbers possible
- 4 - If there is one branch, there is no need for numbering.
- 5 - Place the number of branching.
- 6 - Set dashes and commas

**Don't forget the notes:**

- 1 - There is no need to find the longest chain.
- 2 - The numbering is carried out from the carbon atom associated with the substituted group.
- 3 - When there is more than one substituted group, the carbon atoms are numbered around the ring, provided that the substituted groups get the smallest possible set of numbers.
- 4 - If there are two different groups at the same distance from the numbering, then we resort to the English alphabet.
- 5 - If there is one substituted group connected to the ring, there is no need for numbering.

**Q: Use the IUPAC rules to name the following formulas:**

 <p style="text-align: center;">Cyclopropane</p>	
	
 <p style="text-align: center;">Methyl cyclohexane</p>	
 <p style="text-align: center;">1,2 dimethyl cyclobutane</p>	





**Q - Draw the condensed formula for:**

A) 1,1 - Dimethyl cyclopropane

B) 2,2,4,4 – tetramethylpentane

2-ethyl-3- methyl pentane

1-methyl-3-propyl cyclopentane

1-ethyl-3-propyl cyclopentane

1,2,2,4-tetramethyl cyclohexane

# properties of alkanes:

## A - Physical properties:

- ▶ Alkanes of  $C_1 \rightarrow C_4$  : **Gases** (example : natural constituents of natural gas) as they have low molecular mass and weak London dispersion forces between their molecules.
- ▶ Alkanes of  $C_5 \rightarrow C_{10}$  : **liquids** (example : Kerosene and gasoline) as they have higher molecular mass and an increasing in London dispersion forces between their molecules.
- ▶ Alkanes of  $C_{11} \rightarrow C_{\infty}$  : **solids** (example : Paraffin wax)

**Explain:** Alkanes of high carbon atoms are more united and have a higher boiling point.

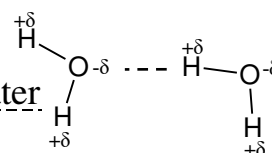
Due to an increase in the molecular mass, which leads to an increase in London dispersion force and an increase in attraction force.

**Explain:** Alkanes are Non-polar molecules: Because the bond is carbon - carbon is non-polar

**Explain:** Alkanes are good solvents for other non-polar materials: because alkanes are non-polar, and like dissolves like.

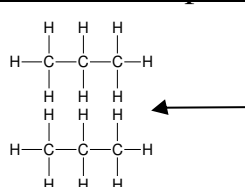
**Explain:** there is significant difference between boiling point of water and methane, use the information in the following table.

In water: There are strong hydrogen bonds between water molecules, which increase the boiling point of water



Substance and formula	Water (H <sub>2</sub> O)	Methane (CH <sub>4</sub> )
Molecular mass	18 amu	16 amu
State at room temperature	liquid	gas
Boiling point	100°C	-162°C
Melting point	0°C	-182°C

In methane: the particles are non-polar, there is weak London dispersion forces among methane molecules, so there is low boiling point



**Explain:** The boiling point of decane is higher than that of the pentane.

Because of the higher the molecular mass, the greater London dispersion forces between the molecules, and thus the greater the boiling point.

**Explain:** Alkanes or hydrocarbons (such as lubricating oil) not mixed in water.

Because like dissolves like, so the attraction forces between the non-polar alkane molecules with each other are stronger than the attraction forces between the non-polar alkanes and the polar water.

**Note:** Alkanes and hydrocarbons (non-polar) are dissolved in non-polar solvents such as toluene and benzene (both non-polar).

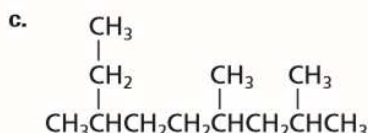
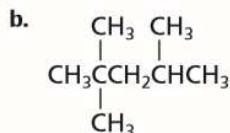
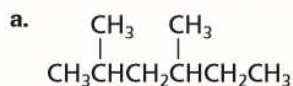
## A - Chemical properties:

**Chemical reaction principle:** Most chemical reactions occur when a reactant with a full electrical charge such as an ion or a partial charge such as a polar molecule is attracted to another substance with an opposite charge.

**Explain:** Weak chemical activity of alkanes.

- 1 - Because its molecules are non-polar, so their attraction to ions or polar molecules is very weak
- 2- The C-C and C-H bonds are relatively strong.

8. Use the IUPAC rules to name the following structures.

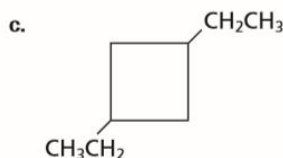
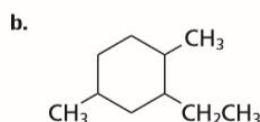
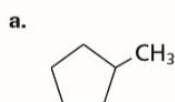


9. **Challenge** Draw the structures of the following branched-chain alkanes.

- 2,3-dimethyl-5-propyldecane
- 3,4,5-triethyloctane

PRACTICE Problems

10. Use IUPAC rules to name the following structures.



11. **Challenge** Draw the structures of the following cycloalkanes.

- 1-ethyl-3-propylcyclopentane
- 1,2,2,4-tetramethylcyclohexane

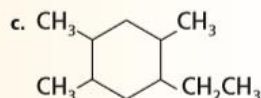
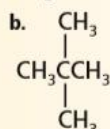
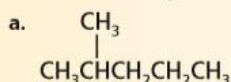
## Section 21.2 Assessment

### Section Summary

- ▶ Alkanes contain only single bonds between carbon atoms.
- ▶ Alkanes and other organic compounds are best represented by structural formulas and can be named using systematic rules determined by the International Union of Pure and Applied Chemistry (IUPAC).
- ▶ Alkanes that contain hydrocarbon rings are called cyclic alkanes.

12. **MAIN Idea** Describe the main structural characteristics of alkane molecules.

13. **Name** the following structures using IUPAC rules.



14. **Describe** the general properties of alkanes.

15. **Draw** the molecular structure for each of the following.

a. 3, 4-diethylheptane

c. 1-ethyl-4-methylcyclohexane

b. 4-isopropyl-3-methyldecane

d. 1,2-dimethylcyclopropane

16. **Interpret Chemical Structures** Why is the name 3-butylpentane incorrect? Based on this name, write the structural formula for the compound. What is the correct IUPAC name for 3-butylpentane?

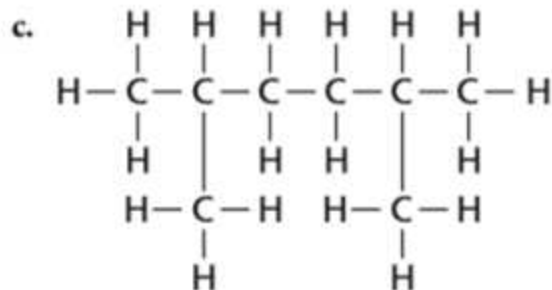
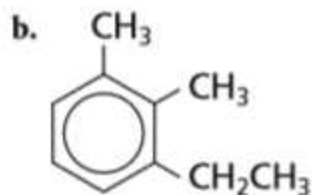
## Section 21.2

### Mastering Concepts

48. Describe the characteristics of a homologous series of hydrocarbons.
49. **Fuels** Name three alkanes used as fuels and describe an additional application for each.
50. Draw the structural formula of each of the following.
- a. ethane
  - b. hexane
  - c. propane
  - d. heptane
51. Write the condensed structural formulas for the alkanes in the previous question.
52. Write the name and draw the structure of the alkyl group that corresponds to each of the following alkanes.
- a. methane
  - b. butane
  - c. octane
53. How does the structure of a cycloalkane differ from that of a straight-chain or branched-chain alkane?
54. **Freezing and Boiling Points** Use water and methane to explain how intermolecular attractions generally effect the boiling and freezing points of a substance.

## Mastering Problems

55. Name the compound represented by each of the following structural formulas.



56. Draw full structural formulas for the following compounds.

a. heptane

b. 2-methylhexane

c. 2,3-dimethylpentane

d. 2,2-dimethylpropane

57. Draw condensed structural formulas for the following compounds. Use line structures for rings.

a. 1,2-dimethylcyclopropane

b. 1,1-diethyl-2-methylcyclopentane

58. Name the compound represented by each of the following structural formulas.

