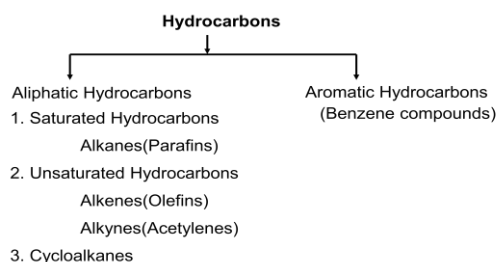


ALKANES

Introduction

- Hydrocarbons, as the name implies are compounds whose molecules contain only carbon and hydrogen.
- They are extracted from petroleum, natural gas and coal.



Petroleum products

1. Alkanes

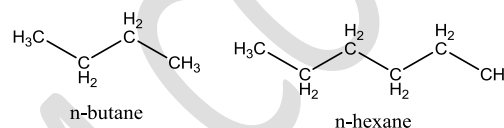
- Contain C-C and C-H sigma bonds.
- Known as paraffin, meaning inert.
- General formula is C_nH_{2n+2} , n is number of carbon atoms.
- First four members have common names, methane, ethane, propane and butane.
- Names end with -ane suffix.
- In the names "latin number + -ane" is used, for example penta + ane = pentane
- $-CH_2-$, methylene, is difference between consecutive

Fraction	Size	Boiling-Point Range ($^{\circ}C$)	Uses
Gas	C_1 to C_5	-160 to 30	Gaseous fuel,
			production of H_2
Gasoline	C_5 to C_{12}	30 to 200	Motor fuel
Kerosene, fuel-oil	C_{12} to C_{18}	180 to 400	Diesel fuel, furnace fuel, cracking
Lubricants	C_{16} and up	350 and up	Lubricants
Paraffins	C_{20} and up	Low-melting solids	Candles, matches
Asphalt	C_{36} and up	Gummy residues	Surfacing roads

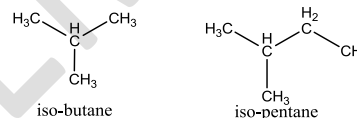
alkanes, forming homologous series.

Number of carbon atoms	Name	Formula
1	methane	CH_4
2	ethane	CH_3-CH_3
3	propane	$CH_3-CH_2-CH_3$
4	butane	$CH_3-CH_2-CH_2-CH_3$
5	pentane	$CH_3-CH_2-CH_2-CH_2-CH_3$
6	hexane	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$
7	heptane	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$
8	octane	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$
9	nonane	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$
10	decane	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$

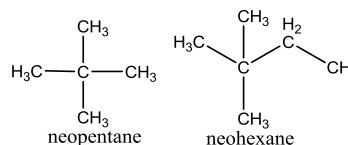
- Straight chain alkanes take n- in front of name, meaning "normal" and shows the alkane is unbranched.



- In branched alkanes, if one methyl, $-CH_3$, group is on the second carbon the "iso-" prefix is added to name.



- Additionally if there are two methyl, $-CH_3$, groups are on the second carbon the "neo-" prefix is added to name.
- Additionally if there are two methyl, $-CH_3$, groups are on the second carbon the "neo-" prefix is added to name.



Example 1

What is the molecular formula of the alkane having the 58 g/mole molecular mass?

Example 2

14.4 g of an alkane, when analyzed, is found to contain 12 g carbon. What is its molecular formula?

Example 3

If a 3 g sample of hydrocarbon is burned, 5.4 g of water vapor is produced. What is the molecular formula of hydrocarbon?

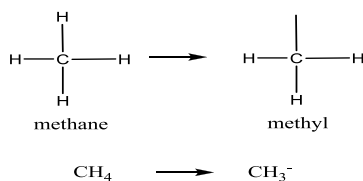
Example 4

When the CO_2 gas produced by the combustion 0.2 mol of an alkane is passed into limewater ($Ca(OH)_2$), 40 g of calcium carbonate precipitates. What is the molecular formula of the alkane?

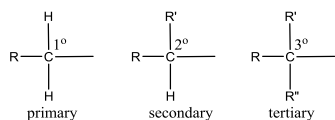
2. Alkyl Groups

- If one hydrogen atom is removed from an alkane, an alkyl group is formed.
- General formula of alkyl groups is C_nH_{2n+1} .
- Instead of the “-ane” suffix in alkanes, “-yl” is used for naming of alkyl groups.
- They are represented as “R”, meaning radical.
- A carbon atom in an alkane can be named as primary, secondary or tertiary according to number alkyl groups bonded to it.
- $C_nH_{2n+2} \rightarrow C_nH_{2n+1}$
Alkane Alkyl

Example 5

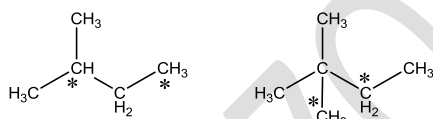


Example 6



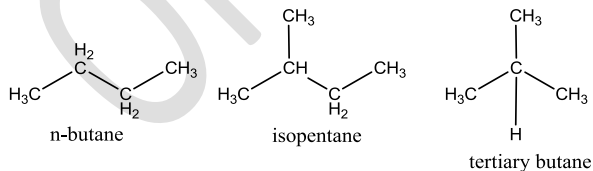
Example 7

Name the carbon atoms shown in the following molecules as primary, secondary or tertiary.

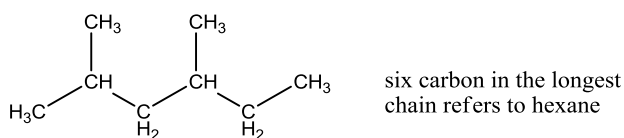


3. Nomenclature of Alkanes

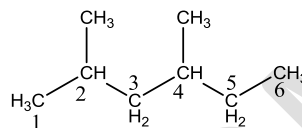
- For simple alkanes common names are used.
- For the branched complex alkanes IUPAC system is used. In the IUPAC system following rules can be used.



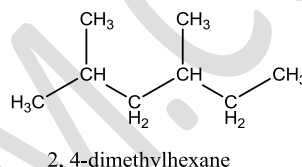
1. Determine the longest number of continuous carbon atom chain. This gives the parent name of alkane.



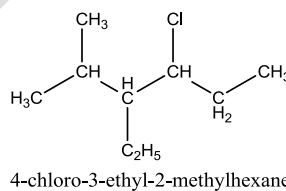
2. Number the carbon atoms in the longest chain, starting nearer at the end nearer to the branched.



3. Show the position of groups bonded to parent chain, if there are more than one identical groups, use -di, -tri or -tetra prefixes. Some important groups are -F (fluoro), -Cl (chloro), -Br (bromo), -I (iodo), -NO₂(nitro), -OH (hydroxyl), and -NH₂(amino)

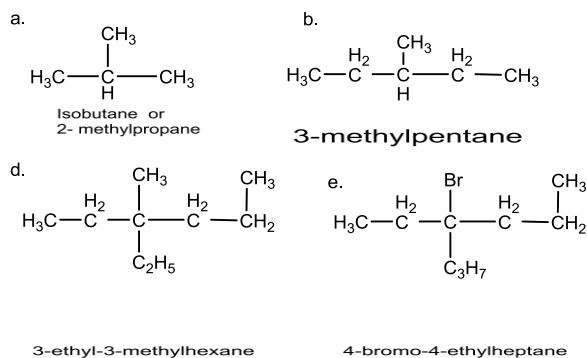


4. When two or more different groups are bonded to the carbon chain, they are ordered alphabetically.



Example 8

Name the following structures



Example 9

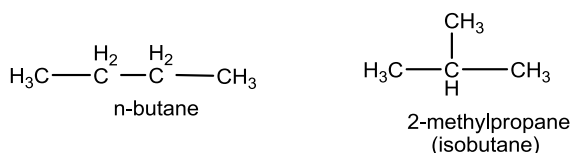
Draw the structures of following alkanes.

- 3-ethyl-2-methylpentane
- 1,3-dibromopropane
- 2,2,3,3-tetramethylbutane
- 2,2,4-trimethylpentane
- 2-chloro-2,3-dimethyl-3-ethylheptane

f. 5-ethyl-2-methylheptane

4. Isomerism in Alkanes

- Compounds having same molecular formula but different structural formula are said to be isomers.
- First three members of alkanes do not have isomers.
- Physical and chemical properties of isomers are different.



Example 10

Write the structural formulae and the IUPAC name of possible isomers of hexane, C₆H₁₄.

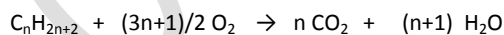
5. Physical Properties of Alkanes

- Alkanes are non polar molecules, only van der waals forces are responsible for the attractions between molecules.
- C₁-C₄ are gases, C₅-C₁₇ are liquids, and the rest are solids.
- Bp, Mp, and densities of alkanes increase by the increasing number of carbon atom.
- They are generally tasteless, odorless and colorless.
- Branching decreases boiling point.
- They are insoluble in water, but soluble in organic solvents such as benzene and carbon tetrachloride.

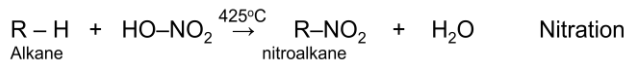
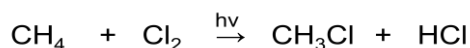
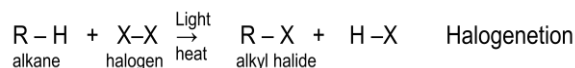
6. Chemical Properties of Alkanes

- Another name for alkanes is paraffin, meaning inert. They are chemically quite unreactive.
- They do not react with dilute acids (HCl, H₂SO₄), active metals (Na, K) and strong oxidizing agents (KMnO₄, Na₂Cr₂O₄).
- They only undergo combustion and substitution reaction with halogens. They can be nitrated under high pressure.

1. Combustion Reaction



2. Substitution Reaction

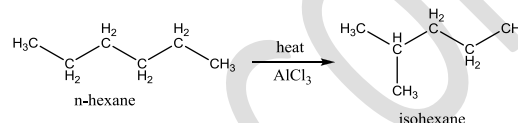


3. Cracking Reactions

- Higher alkanes are converted into smaller alkanes and alkenes at high temperature. When a catalyst is used in the process, it is known as catalytic cracking.

4. Isomerization Reaction

Straight-chain alkanes are converted into branched alkanes



Example 11

When 8.8 g of an alkane is burned completely, 26.4 g of carbon dioxide and 14.4 g of water are produced. What is the molecular formula of the alkane?

Example 12

To burn a mixture of 33.6 L of methane and propane gas at STP, 144 g of oxygen gas are required. According to this information, what is the total mass of the original mixture? (H:1, C:12, O:16)

Example 13

What is the pressure of CO₂ gas in 2-L container which is produced from the combustion of 7.2 g of C₅H₁₂ at 27°C?

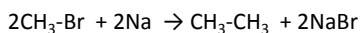
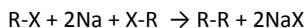
7. Preparation of Alkanes

Main sources of alkanes are crude oil, natural gas and coal. Many useful alkanes are obtained from fractional distillation of petroleum

1. Wurtz Synthesis

This method was first used by Adolph Wurtz in 1854.

Methane cannot be produced in this process.



Example 14

Which alkyl halides can be used to prepare pentane by the Wurtz synthesis.

Example 15

What is(are) the products of the reaction of 2-chloropropane and 1-bromoethane with excess sodium metal?

2. Hydration of Grignard Compounds

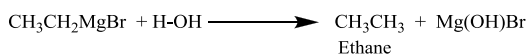
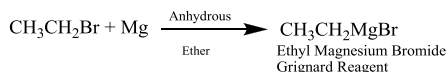


This method was first used by Victor Grignard in 1912.

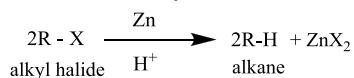
Example 15

Prepare ethane by using Grignard reagent.

Solution



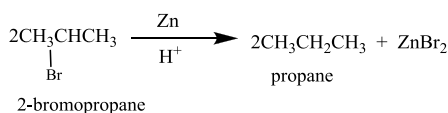
3. Reduction of Alkyl Halides



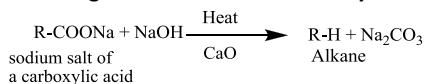
Example 16

Prepare propane by using 2-bromopropane.

Solution



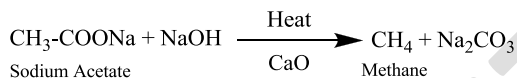
4. Heating the Metal Salts of Carboxylic Acids



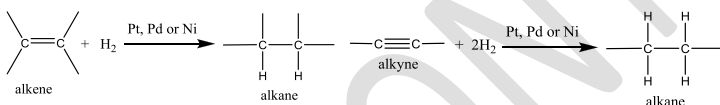
Example 17

Prepare methane by using sodium acetate.

Solution



5. Hydrogenation of Unsaturated Hydrocarbons

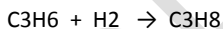


Example 18

5 mol mixture of C₃H₆ and C₃H₈ is reacted with 2 mol of H₂ gas. What is the total volume of gases at STP when the reaction is completed?

Solution

In the mixture only C₃H₆ reacts with H₂.



2 mol H₂ → 2 mol C₃H₆, the mol of C₃H₈ = 5 - 2 = 3 mol is unreacted.

nT = 2 mol C₃H₈ produced + 3 mol C₃H₈ unreacted = 5 mol

V = 5 × 22.4 = 112 L

8. Methane

It is found in mines and in natural gas.

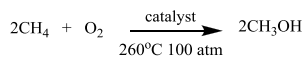
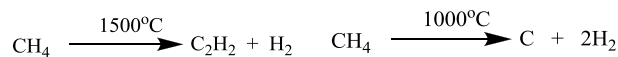
It is also known as marsh gas and is formed by decomposition of plants in the absence of oxygen.

It is colorless and odorless gas.

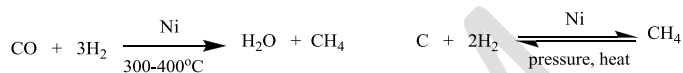
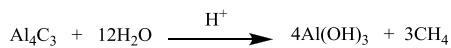
It is insoluble in water, but soluble in benzene and gasoline.

10-15% of methane in air may cause an explosion. It is called in mines "firedamp explosions".

It burns with a light blue flame.



Preparation



Example 18

What is the percent of a 150 g of Al₄C₃ sample that produces 67.2 L of CH₄ gas when put in water? (Al:27, H:1, C:12)

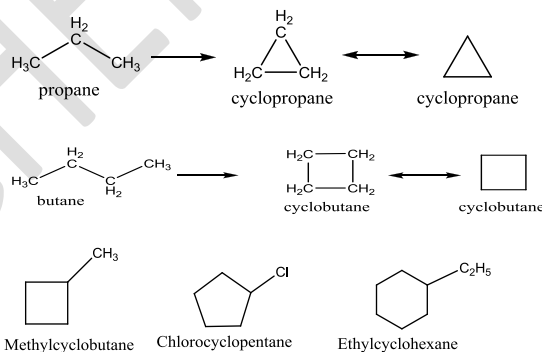
9. Cycloalkanes

Alkanes bonded to one another in a ring formation is called cycloalkanes.

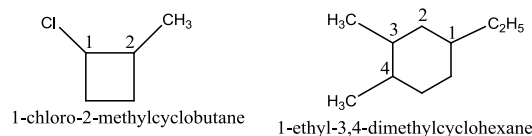
General formula is C_nH_{2n}.

Nomenclature of Cycloalkanes

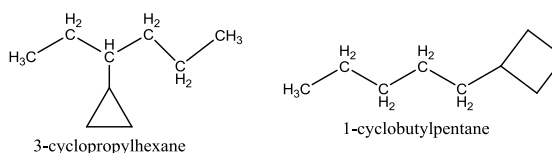
Use *cyclo-* prefix to the names of alkanes.



If there are more than one substituent in the ring, the ring is numbered starting with the substituent first in the alphabet, and numbered in the direction which gives the lowest number for the second substituent.



If the number of carbon atom in the ring is less than that is in the substituent, then they are named as cycloalkylalkanes.



Physical Properties

Melting point, boiling point and densities of cycloalkanes are different from the alkanes possessing the same number of alkanes.

Melting and boiling points increase as the number of carbon atom increases in the ring.

Chemical Properties

Cycloalkanes with more than 5 carbon atom undergo substitution reaction.

Cycloalkanes with 3 or 4 carbon atoms undergo addition reaction

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