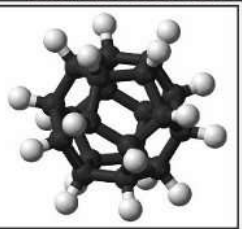
11 CHAPTER HYDROCARBONS



LAST
HOPE
STUDY

Student Learning Outcomes

After studying this chapter, students will be able to:

- Describe the properties of alkanes as being generally. Unreactive except in terms of combustion and substitution by chlorine
- State that in a- substitution: reaction. one atom or-group of atoms is replaced by another atom or group of atoms
- Describe the substitution reaction of alkanes with chlorine as a photochemical reaction, and draw the structural or displayed formulae of the products limited.
- Describe, using symbol equations, preparation-of alkanes from cracking of larger hydrocarbons hydrogenation of alkenes and alkynes, and reduction of alkyl halides.

INTRODUCTION

SHORT QUESTIONS

Q.1 What are the organic compounds? *(Knowledge Base)* (GRW 2017, SGD 2016 G-I)

Ans:

ORGANIC COMPOUNDS

Definition:

*"Organic compounds are **hydrocarbons** (compounds of carbon and hydrogen) and their derivatives, in which covalently bonded **carbon is an essential constituent**".*

Examples:

- Glucose ($C_6H_{12}O_6$)
- Methane (CH_4)
- Alcohol (C_2H_5OH)

Number of Organic Compounds:

Several million (about ten millions) organic compounds are known to exist naturally or have been synthesized in the laboratory.

Q.2 What is organic chemistry? *(Knowledge Base)* (LHR 2013, DGK 2016 G-I)

Ans:

ORGANIC CHEMISTRY

Definition:

"The branch of chemistry which deals with the study of hydrocarbons and their derivatives is known as organic chemistry".

Scope:

In this branch we study petroleum, petrochemicals, pharmaceuticals etc.

Q.3 Which are inorganic compounds which contain carbon? *(Knowledge Base)*

Ans:

INORGANIC COMPOUNDS CONTAINING CARBON

The ionic compounds containing carbon but classified as inorganic compounds are:

- Carbonates e.g. ($CaCO_3$)
- Hydrogen carbonates e.g. ($NaHCO_3$)
- Cyanides e.g. (NaCN)
- Carbides e.g. (CaC_2)
- cyanates e.g. (KCNO)
- the oxides of carbon e.g. (CO, CO_2)

They are not treated as organic compounds because their properties are quite different from those of organic compounds.

In organic chemistry we study petroleum, petrochemicals, pharmaceuticals etc.

Q.4 What is the composition of organic compounds? ***(Knowledge Base)***

Ans: **COMPOSITION OF ORGANIC COMPOUNDS**

(i) **Essential Element**

All the organic compounds are known to contain **carbon** as an essential element. This fact has led us to define organic chemistry as the chemistry of carbon compounds.

(ii) **Other Elements**

Apart from carbon, **most of the organic compounds** contain **hydrogen and oxygen** as well. **Some** of the organic compounds contain **nitrogen, sulphur, halogens, metals etc.**

Q.5 Enlist some important characteristics of organic compounds? ***(Knowledge Base)***

Ans: **IMPORTANT CHARACTERISTICS OF ORGANIC COMPOUNDS**

Some important characteristics of organic compounds are as follows:

(i) Organic compounds are famous for their **large number and diverse behaviour**.

(ii) **Several million organic compounds** are known to exist naturally or have been synthesized in the laboratory.

(iii) Organic molecules are **usually large and more complex** in nature.

Examples

They include life molecules like:

- Proteins
- Enzymes
- Carbohydrates
- Lipids
- Vitamins
- nucleic acids
- pharmaceuticals
- synthetic fibres, etc.

(iv) The number of compounds **formed by the element carbon** is **far more than the total number of compounds** formed by all the rest of elements put together. This is due to some unique properties of carbon.

Q.6 Why carbon forms covalent compounds?

Ans: **CARBON FORMS COVALENT COMPOUNDS**

The element carbon is present at the center of the periodic table and it is energetically not possible for it to gain or lose electrons to form ionic bonds. Therefore, it forms four covalent bonds by sharing of electrons.

Q.7 Why carbon forms strong and stable bond?

Ans: **CARBON FORMS COVALENT COMPOUNDS**

Because of their small size, these covalent bonds are short and strong enabling carbon to give strong and stable bond with itself and with hydrogen, oxygen and nitrogen.

Q.8 Why carbon forms long, straight, and branched chains and rings??

Ans: **Long, Straight, And Branched Chains And Rings**

Carbon forms long, straight, and branched chains and rings due to:

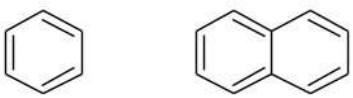
- the property of catenation (*self-linking property of carbon).*
- Because of small size of carbon atoms, the covalent bonds are short and strong enabling carbon to give strong and stable bond with itself and with hydrogen, oxygen and nitrogen.

Q.9 What is meant by catenation?

Ans: **CATENATION**

Definition

The self-linking property of carbon is called catenation and due to this it forms long, straight and branched chains and rings.



$H_3C-CH_2-CH_2-CH_3$

Straight chain $(n-Butane)$

Q.10 What type of bonds are formed by carbon in organic compounds?

Ans: **Bonding of carbon**

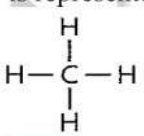
Carbon atom mostly forms covalent bonds with carbon, hydrogen, oxygen, nitrogen and halogens.

Saturated Compounds

Compounds in which carbon forms single bond with other atoms are called saturated compounds. These compounds are generally represented by their structural formulas.

Example

Methane a saturated compound/ is represented by the following structural formula.



or its condensed form is CH_4

Example

- C_2H_6
- CH_3Cl
- CH_3OH
- CH_3NH_2 etc.

Unsaturated Compounds

Compounds in which carbon forms multiple (double and triple) covalent bonds with other atoms are called unsaturated compounds.

Q.11 What are the types of formulae of organic compounds? ***(K.B + U.B.)***

(GRW 2014, DGK 2017, MTN 2016 G-I)

Ans: **TYPES OF FORMULAE OF ORGANIC COMPOUNDS**

There are four types of formulae of organic compounds:

(i) Molecular formula
(ii) Structural formula
(iii) Condensed formula
(iv) Dot and cross formula

EXERCISE

What do you understand by the term structural formula of an organic compound?

Ans: **STRUCTURAL FORMULA**

*"Structural formula of a compound represents the **exact arrangement** of the **different atoms** of various elements present in a molecule of a substance".*

Representation of Bonds:

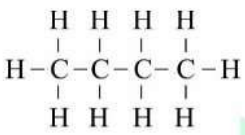
In a structural formula the bonds between bonded atoms are shown as follows:

- Single bond is represented by a single line (–)
- Double bond by two lines (=)
- Triple bond by three lines (≡)

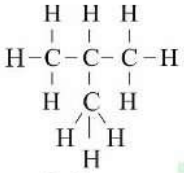
Organic compounds may have same molecular formulae but different structural formulae.

Example:

Structural formulae of butane (C_4H_{10}) are:



n-butane



isobutane

MULTIPLE CHOICE QUESTIONS

1. General formula of alkanes is: ***(K.B)*** **(GRW 2014)**

(A) C_nH_{2n-2} (B) C_nH_{2n+2}

(C) C_nH_{2n} (D) C_nH_{2n+1}

2. The number of hydrogen atoms in butane is: ***(K.B)*** **(LHR 2015)**

(A) 10 (B) 6

(C) 8 (D) 4

3. Which one is methyl radical? ***(K.B)*** **(GRW 2015)**

(A) $–CH_2–$ (B) $CH_3–$

(C) CH_4 (D) $CH_3 – CH_3$

4. Which one of these is a saturated hydrocarbon? ***(K.B)*** **(GRW 2016)**

(A) C_2H_4 (B) C_3H_6

(C) C_4H_8 (D) C_5H_{12}

5. The density of alkanes increases with the increase of: ***(K.B)***

(A) M.P (B) B.P

(C) Molecular size (D) Bonds

11.1 HYROCARBONS

LONG QUESTIONS

Q.1 What are hydrocarbons? ***(Knowledge Base)***

Ans: **HYDROCARBONS**

Definition:

"The organic compounds which consist of carbon and hydrogen only are called hydrocarbons".

Examples:

- Methane (CH_4)
- Ethane (C_2H_6)

- Propane (C_3H_8)

Simple organic compound

The family of hydrocarbons constitutes a very large number of simple organic compounds containing carbon and hydrogen only.

Q.2 What is importance of hydrocarbons? ***(Knowledge Base)***

Ans: **IMPORTANCE OF HYDROCARBONS**

(i) As fuel

- Most of the fuels which we use every day,
- Example
- Natural gas, LPG (Liquefied Petroleum Gas)
- CNG (Compressed Natural Gas)
- Petrol
- Diesel
- Kerosene oil, are all simple hydrocarbons.

(ii) As a feedstock

These hydrocarbons also serve as a feedstock to prepare more complex and useful compounds like

- Plastics
- Medicines
- Synthetic fibres
- Paints
- Varnishes.

(iii) **As Starting Materials:**

Hydrocarbons are the starting materials for the synthesis of organic chemicals of commercial importance.

Independence of alkanes

Methane is the simplest alkane and it is mainly used as a fuel but it is also used to make hydrogen gas, carbon black, carbon disulphide, chloroform, hydrocyanic acid, etc.

Q.3 What are general classes of hydrocarbons? ***(Knowledge Base)***

Ans: **GENERAL CLASSES OF HYDROCARBONS**

Hydrocarbons are classified into several structural types called:

- Alkanes
- Alkenes
- Alkynes
- Aromatics

Hydrocarbons are further classified as saturated and unsaturated.

SHORT QUESTIONS

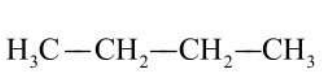
Q.1 What are aliphatic hydrocarbons? ***(Knowledge Base)***

Ans: **ALIPHATIC HYDROCARBONS**

"These are the compounds in which the first and the last carbon are not directly joined to each other".

These may be straight or branched chain hydrocarbons.

Examples:



n-butane

Branched chain (isobutane)

Q.2 Define catenation. ***(Knowledge Base)*** **(GRW 2017, FSD 2016 G-I, II)**

Ans: Answer given on page # 284

Q.3 Write the general formulas of alkanes, alkenes and alkynes. ***(Knowledge Base)***

(BWP 2016 G-I)

Ans:

GENERAL FORMULAS

The general formulas of alkanes, alkenes and alkynes are as follows:

- Alkanes: C_nH_{2n+2}
- Alkenes: C_nH_{2n}
- Alkynes: C_nH_{2n-2}

MULTIPLE CHOICE QUESTIONS

1. The simplest class of organic compounds is: *(K.B)*
(A) Carbides (B) Hydrocarbons
(C) Carbonates (D) Nitrates

2. Hydrocarbons are divided into classes: *(K.B)*
(A) 4 (B) 3
(C) 2 (D) 1

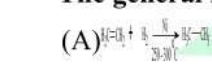
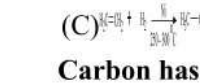
3. Each carbon atom of hydrocarbon has bonds: *(K.B)*
(A) 4 (B) 3
(C) 2 (D) 1

4. Hydrocarbons are _____ and _____ in water. *(K.B)*
(A) Polar, insoluble (B) Non-polar, insoluble
(C) Polar, soluble (D) Non-polar, soluble

5. These are hydrocarbons: *(K.B)*
(A) Fossil fuels (B) Coals
(C) Petroleum (D) All of these

6. Which one is saturated hydrocarbon? *(K.B)* **(LHR 2014), (GRW 2017)**
(A) C_2H_4 (B) C_3H_6
(C) C_4H_8 (D) C_5H_{12}

7. Which one is unsaturated hydrocarbon? *(K.B)* **(LHR 2014)**
(A) $CH_2 = CH_2$ (B) $CH_3 - CH_3$
(C) $CH_3 - CH_2 - CH_3$ (D) Both A and C

8. The general formula of saturated hydrocarbons is: *(K.B)* **(LHR 2015)**
(A)  (B)
(C)  (D) 

9. Carbon has valency: *(K.B)*
(A) 3 (B) 4
(C) 5 (D) 6

10. Which of the following property is not present in hydrocarbons? *(K.B)*
(A) High melting point (B) Non-polar property
(C) Solubility in non-polar solvent (D) Poor conductivity

11. Hydrocarbons having high molecular mass are: *(K.B)*
(A) Gases (B) Liquid
(C) Solids (D) All of these

12. What is the formula of methane? *(K.B)*
(A) CH_3 (B) CH_4
(C) CH_2 (D) C_2H_5

11.2 ALKANES

LONG QUESTIONS

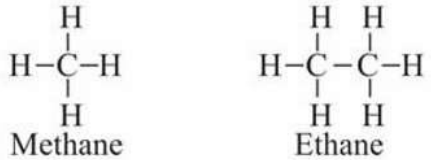
Q.1 What are alkanes? *(Knowledge Base)*

Ans: **ALKANES**

Definition

Alkanes are the simplest family of hydrocarbons with only carbon-carbon and carbon - hydrogen single bond.

Example



In ethane (CH_3—CH_3) both the carbon atoms are fully saturated with single bonds.

General formula

Alkanes are represented by a general formula C_nH_{2n+n} (where n is an integer).

Q.2 Why alkanes are called saturated hydrocarbon or paraffins?

Ans: **ALKANES AS PARAFFINS**

Alkanes are also called saturated hydrocarbons because all the four valencies of carbon in them are fully utilized either by hydrogen atoms or by other carbon atoms through single bonds.

Q.3 Why methane is called parent hydrocarbon?

Ans: **METHANE AS PARENT HYDROCARBON**

Methane being the simplest hydrocarbon, is also called parent hydrocarbon since other organic compounds are considered to be derived from them by replacement of one or more hydrogen atoms by other atoms or group of atoms.

Example:

CH_3OH is obtained by replacement of H – atom of CH_4 with OH.

Q.4 (A) What are the parts of an organic compound?
(B) What is IUPAC nomenclature? How to name an organic compound?

Ans: **(A) PARTS OF NAMES OF ORGANIC COMPOUND**

According to IUPAC system of nomenclature, the entire name of an organic compound has three parts:

1. **Root:**
   It tells us the number of carbon atoms in the longest continuous chain present in the molecule. The roots up to ten carbon atoms are shown in table 11.1.
2. **Suffix:**
   It is added after the root and tells us about the class of organic compounds.
3. **Prefix:**
   It is indicated before the root and tells us about the group or groups attached to the longest chain.

Root	No. of Carbon atoms
Meth-	1
Eth-	2
Prop-	3
But-	4
Pent-	5
Hex-	6
Hept-	7
Oct-	8
Non-	9
Dec-	10

(B) IUPAC NOMENCLATURE

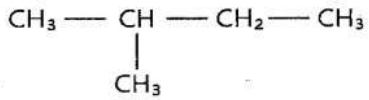
The International Union of Pure & Applied Chemistry has devised a systematic way of naming organic compounds called IUPAC nomenclature.

Why it is not possible to name each and every compound individually?

As a result of the great complexity and large number Table (11.1) of organic compounds, it is not possible to name each and every compound individually.

HOW TO NAME AN ORGANIC COMPOUND?

To explain the above system, let us name the following compound.



Steps involved

(a) Identify the longest continuous chain present in the compound.
(b) Identify the class of organic compounds.
(c) Identify the substituent or substituents if present.

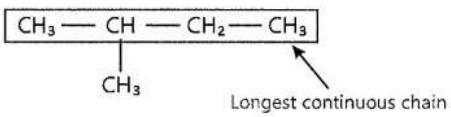
Explanation

(a) Longest chain

This organic compound contains four carbon atoms in the longest continuous chain

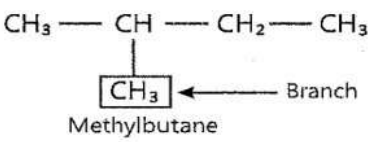
(b) Class of organic compounds

It belongs to the family of organic compounds called Alkanes. The root is therefore But and the suffix-ane added to this. The organic compound will thus be given the name Butane.



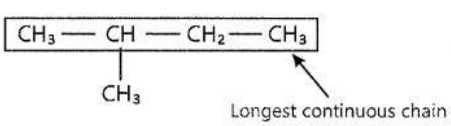
(c) Name of branches

The name of the only branch methyl- will be added to this name as prefix. So the name will become:



(d) Location of branch

To specify where the branch occurs, the longest continuous chain is numbered starting from the end closest to the branch. This number is then attached to this prefix. The name of the above compound will then be:



2-Methylbutane or iso-Butane

Parts of names of organic compound that has no branches

If a compound has no branches, its name will contain only root and suffix.

INTERESTING INFORMATION

DISTINGUISHING FEATURE OF ALKANES

The distinguishing feature of alkanes makes them distinct from other compound is their lack of reactivity towards usual chemical reagents.

EXERCISE

1. Name the following compounds according to IUPAC system of nomenclature.

(i) $(CH_3)_2CH-CH(CH_3)-CH_2-CH_3$ (ii) $(CH_3)_2CH-CH_2-CH_3$

Ans:

(i) Its name is 2,3-Dimethyl- pentane.

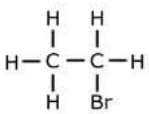
(ii) Its name is 2-Methyl- butane

2. Draw the structural formulae of the following saturated compounds.

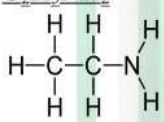
C_2H_5Br, CH_3NH_2, CH_3CH_2OH

Ans: **STRUCTURAL FORMULAS OF COMPOUNDS**

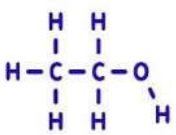
(i) C_2H_5Br



(ii) $C_2H_5NH_2$

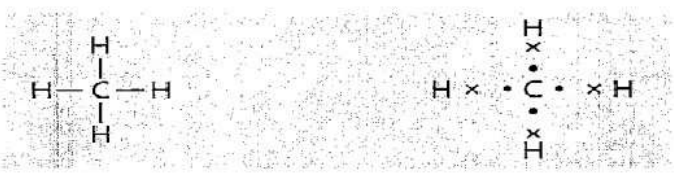


(iii) C_2H_5OH



Electron cross and dot structure of alkanes

Methane



Ethane

Propane

EXERCISE

How many methyl and methylene, group are present in each of the above compounds?

Ans:

Compound	Methyl group	Methylene group
Methane	1	0
Ethane	2	0
Propane	2	1

SHORT QUESTIONS

Q.1 What are alkanes? ***(Knowledge Base)***

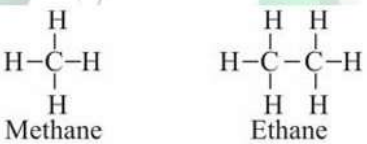
Ans:

ALKANES

Definition

Alkanes are the simplest family of hydrocarbons with only carbon-carbon and carbon - hydrogen single bond.

Example



In ethane (CH_3—CH_3) both the carbon atoms are fully saturated with single bonds.

General formula

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Q.2 Why alkanes are called saturated hydrocarbon or paraffins?

Ans:

ALKANES AS PARAFFINS

Alkanes are also called saturated hydrocarbons because all the four valencies of carbon in them are fully utilized either by hydrogen atoms or by other carbon atoms through single bonds.

Q.3 Why methane is called parent hydrocarbon?

Ans:

METHANE AS PARENT HYDROCARBON

Methane being the simplest hydrocarbon, is also called parent hydrocarbon since other organic compounds are considered to be derived from them by replacement of one or more hydrogen atoms by other atoms or group of atoms.

Example:

CH_3OH is obtained by replacement of H – atom of CH_4 with OH.

MULTIPLE CHOICE QUESTIONS

1. The formula of octane is: ***(K.B)*** **(GRW 2014)**

(A) C_9H_{18} (B) C_8H_{18}

(C) C_8H_{20} (D) C_9H_{20}

2. The number of hydrogen atoms in hexane is: ***(K.B)*** **(LHR 2015)**

(A) 10 (B) 6

(C) 8 (D) 4

3. Which one is methyl radical? ***(K.B)*** **(GRW 2015)**

(A) $–CH_2–$ (B) $CH_3–$

(C) CH_4 (D) $CH_3 – CH_3$

4. Which one of these is a unsaturated hydrocarbon? *(K.B)* **(GRW 2016)**

(A) C_2H_4 (B) C_3H_6
(C) C_4H_8 (D) All of these

5. What is the formula of butane? *(K.B)* **(BWP 2017), (RWP 2017),**

(A) C_3H_8 (B) C_4H_{10}
(C) C_5H_{12} (D) C_6H_{14}

6. Paraffins means: *(K.B)*

(A) Highly reactive (B) Less reactive
(C) Oil forming (D) None of these

11.3 PREPARATION OF ALKANES

LONG QUESTIONS

Q.1 How alkanes can be prepared in laboratory? *(K.B. + U.B. + A.B.)*

Ans:

PREPARATION OF ALKANES

Generally, any member of the alkane series can be prepared by the following methods,

1. Cracking of higher hydrocarbons

Definition

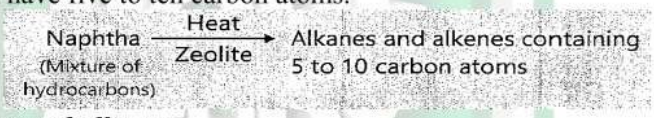
Cracking is the name of a process in which hydrocarbons with higher molecular masses (which are lesser in demand) are broken up into smaller hydrocarbons which are more in demand.

Process

This is done by heating the hydrocarbons at high temperature in the presence of a catalyst.

Cracking of petroleum

Fractional distillation of petroleum gives naphtha which consists of a mixture of liquid hydrocarbons. It is then heated at around 500 ^{0} C in the presence of catalyst called zeolite to give hydrocarbons which have five to ten carbon atoms.



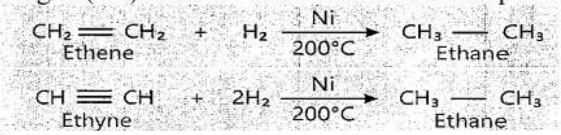
2. Reduction of alkenes and alkynes

Reduction

Addition of hydrogen or atomic hydrogen (H) to a substance is called reduction.

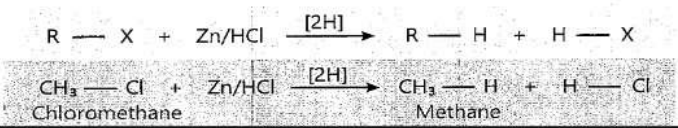
Example

Alkanes can be prepared by reducing alkenes and alkynes with hydrogen gas in the presence of nickel metal as a catalyst. Methane cannot be prepared by this method. The reaction is also called hydrogenation of alkenes and alkynes and is an example of addition reaction. An addition reaction occurs when hydrogen (H2) is added to an unsaturated compound.



3. Reduction of alkyl halides

Alkyl halides (R-X) can be reduced to alkanes with hydrogen generated by reaction of zinc metal with hydrochloric acid.



INTERESTING INFORMATION

IMPORTANCE OF CRACKING HYDROCARBONS

Cracking of hydrocarbons helps balance the availability of petroleum fractions with the demand for

them. When cracking transforms bigger hydrocarbons into small hydrocarbons, the fuel supply is increased. That helps to balance demand with supply.

INTERESTING INFORMATION

APPLICATION OF REDUCTION OF UNSATURATED COMPOUNDS

Reduction reaction of unsaturated compounds is used to prepare banaspati ghee and margarine.

SHORT QUESTIONS

Q.1 Which is the simplest alkane? ***(Knowledge Base)***

Ans: **SIMPLEST ALKANE**

The simplest alkane is methane having formula CH_4.

Q.2 Give the structure of following compounds: isopentane and isobutane.

(Understanding Base)

Ans: **STRUCTURES OF ISOPENTANE AND ISOBUTANE**

- Isopentane:

$$H_3C-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_3$$

- Isobutane:

$$H_3C-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$$

Q.3 Why the burning of alkanes requires sufficient supply of oxygen?

(Understanding Base)

Ans: **SUFFICIENT OXYGEN FOR BURNING**

The burning of alkanes requires sufficient supply of oxygen because complete burning of alkanes requires sufficient supply of oxygen to form CO_2, H_2O and heat. Otherwise alkanes undergo incomplete combustion in the limited supply of oxygen, as a result carbon monoxide is produced which is poisonous gas and causes air pollution.

$$3CH_4 + 4O_2 \longrightarrow 2CO + C + 6H_2O$$

Q.4 What do you mean by halogenation? Give the reaction of methane with chlorine in bright sunlight. ***(Knowledge Base)***

Ans: **HALOGENATION**

"*Addition of halogen to a substance is called halogenation".*

OR

"A reaction in which one or more hydrogen atoms of a saturated compound are replaced with some other atoms like halogen atom is called halogenation".

Reaction of Methane with Chlorine

In direct sunlight reaction is explosive and carbon is deposited.

$$CH_4 + 2Cl_2 \xrightarrow[\text{Sunlight}]{\text{Bright}} C + 4HCl$$

MULTIPLE CHOICE QUESTIONS

1. The reduction of alkyl halides takes place in the presence of: ***(K.B)*** **(LHR 2015)**

(A) Cu / HCl (B) Mg / HCl

(C) Na / HCl (D) Zn / HCl

2. Which one of these is a saturated hydrocarbon? ***(K.B)*** **(GRW 2016)**

(A) C_2H_4 (B) C_3H_6

(C) C_4H_8 (D) C_5H_{12}

11.4 IMPORTANT REACTIONS

LONG QUESTIONS

Q.1 What are the uses of alkanes? ***(Knowledge Base)*** **(SGD 2016 G-II)**

Ans: **USES OF ALKANES**

Why are alkanes called paraffin?

Alkanes are sometimes reffered to as paraffins which means "little affinity". This term describes their behaviour, for alkanes show little chemical affinity for other substances and are chemically inert to most laboratory reagents.

Reaction of alkanes

Alkanes do react with chlorine and oxygen under suitable conditions.

Un-reactivity of alkanes

The unreactivity of alkanes may be explained on the basis of the non-polarity of the bonds present in them. The electronegativity values of carbon (2.6) and hydrogen (2.1) do not differ appreciably and the bonding electrons between C — H and C — C bond, are almost equally shared. This fact makes alkanes almost nonpolar. In view of this, the reagents like acids, alkanes, oxidizing agents find no reaction site in alkane molecules to which they could be attached.

1. **Halogenation**

Substitution reaction

Alkanes give substitution reactions. The reactions which involve the replacement of hydrogen of alkanes by an atom or a group of atoms like halogen are called substitution reactions.

Halogenation of alkanes

Alkanes react with halogens especially chlorine to give alkyl halides. Since these substitution reactions are carried out in the presence of UV light, these are called photochemical substitution reactions.

Why substitution reaction of alkanes are called photo-chemical substitution reaction?

$$\underset{\text{Methane}}{CH_4} + Cl_2 \xrightarrow{h\nu} \underset{\text{Chloromethane}}{CH_3 - Cl} + H - Cl$$

The reaction may proceed ahead and all the hydrogen atoms attached with carbon of the methane are successively replaced by chlorine atoms.

$$CH_3 - Cl + Cl_2 \xrightarrow{h\nu} \underset{\text{Dichloromethane}}{CH_2Cl_2} + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow{h\nu} \underset{\text{Trichloromethane or chloroform}}{CHCl_3} + HCl$$

$$CHCl_3 + Cl_2 \xrightarrow{h\nu} \underset{\text{Tetrachloromethane or carbon tetrachloride}}{CCl_4} + HCl$$

2. **Combustion**

Alkanes burn in oxygen or air to form CO_2 and H_2O with the evolution of large amount of heat. The reaction is called combustion.

$$\underset{\text{Methane}}{CH_4\,(g)} + 2O_2\,(g) \longrightarrow CO_2 + 2H_2O\,(g) + \text{heat}$$

$$\underset{\text{Ethane}}{2CH_3 - CH_3\,(g)} + 7O_2\,(g) \longrightarrow 4CO_2 + 6H_2O\,(g) + \text{heat}$$

INTERESTING INFORMATION

MAIN CAUSE OF EXPLOSION AT HOMES

A mixture of natural gas (methane) and air may explode when ignited. This is the main cause of explosion at homes where gas leakage occurs.

EXERCISE

Q.1 In the reduction of alkyl halides with Zn / HCI, alkyl halide is being reduced, which species in this reaction is being oxidized?

Ans: **SPECIES OXIDIZED**

In the reduction of alkyl halides with Zn/HCl, the zinc (Zn) is being oxidized.

Q.2 During the combustion reaction of ethane, bonds are being broken and which are being formed?

Ans: **BONDS BEING BROKEN AND BEING FORMED**

During the combustion reaction of ethane, the C-C and C-H bonds in ethane molecule are being broken, and new C=O bonds in carbon dioxide and O-H bonds in water molecules are being formed.

Q.3 What products other than CH_3Cl are formed when methane reacts with chlorine gas?

Ans: **PRODUCTS OF METHANE WITH CHLORINE**

When methane reacts with chlorine gas, the products other than CH_3Cl are

- dichloromethane (CH_2Cl_2)
- trichloromethane ($CHCl_3$)
- tetrachloromethane (CCl_4)

The formation of products depends on the amount of chlorine present.

SHORT QUESTIONS

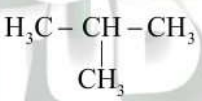
Q.1 Give the structure of following compounds: isopentane and isobutane.

(Understanding Base)

Ans: **STRUCTURES OF ISOPENTANE AND ISOBUTANE**

- Isopentane:

- Isobutane:



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(Understanding Base)

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$$3CH_4 + 4O_2 \longrightarrow 2CO + C + 6H_2O$$

Q.3 What do you mean by halogenation? Give the reaction of methane with chlorine in bright sunlight. *(Knowledge Base)*

Ans: **HALOGENATION**

"*Addition of halogen to a substance is called halogenation".*

OR

"A reaction in which one or more hydrogen atoms of a saturated compound are replaced with some other atoms like halogen atom is called halogenation".

Reaction of Methane with Chlorine

In direct sunlight reaction is explosive and carbon is deposited.

$$CH_4 + 2Cl_2 \xrightarrow[\text{Sunlight}]{\text{Bright}} C + 4HCl$$

MULTIPLE CHOICE QUESTIONS

1. The chemical formula of chloroform: *(K.B)* **(GRW 2016)**

(A) CH_3Cl (B) CH_2Cl_2

(C) $CHCl_3$ (D) CCl_4

2. Which one is the characteristic property of alkanes? *(K.B)*

(A) Displacement reactions (B) Double displacement reaction

(C) Substitution reactions (D) Redox reaction

3. Incomplete combustion of alkanes produces: *(K.B)*

(A) Carbon dioxide (B) Oxygen

(C) Chlorine gas (D) Carbon monoxide

ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	B	**2**	A	**3**	B	**4**	D	**5**	C

11.1 HYDROCARBONS

1	B	**2**	A	**3**	A	**4**	B	5	D
6	D	**7**	A	**8**	A	**9**	B	10	A
11	C	**12**	B						

11.2 ALKANES

1	B	**2**	B	**3**	B	4	B	5	B
6	B								

11.3 PREPARATION OF ALKANES

1	D	**2**	D				

11.4 IMPORTANT REACTIONS

1	C	**2**	C	**3**			D

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

Tick () the correct answer.

1. Which other atom is almost always present along with carbon atom in all organic compounds?

(A) oxygen (B) nitrogen

(C) Hydrogen (D) Halogen

2. Which other metal can be used to reduce alkyl halides?

(A) Al (B) Mg

(C) Ni (D) CO

3. **If naphtha undergoes a combustion reaction what products do you expect to form?**

(A) Alkanes (B) Alkenes

(C) CO_2 and H_2O (D) Both alkanes and alkenes

4. Why does a mixture of zinc and hydrochloric acid acts as a reducing agent?

(A) Because zinc acts as a reducing agent.

(B) Because atomic hydrogen is produced with Zn / HCI which acts as a reducing agent.

(C) Because molecular hydrogen is produced with Zn / HCI which acts as a reducing agent.

(D) Because chloride ions are produced with Zn / HCI which act as a reducing agent.

5. **Which alkane will evolve the most amount of heat when it is burnt with oxygen?**

(A) Ethane (B) Propane

(C) Butane (D) iso-Butane

6. Which reaction is not given by alkanes?

(A) Substitution (B) Combustion

(C) Addition (D) Cracking

7. Which hydrocarbon is responsible for explosions in coal mines?

(A) Butane (B) Pentane

(C) Methane (D) Ethene

8. Which product will be formed when ethyl bromide (C_2H_5Br) is treated with Zn/HCI

(A) CH_4 (B) CH_3--CH_3

(C) $CH_3 - CH_2 - CH_2 - CH_3$ (D) $CH_3 - CH_2 - CH_3$

9. **Which of the following is not a process of halogenation of alkanes?**

(A) Cracking (B) Chlorination

(C) Bromination (D) Iodination

10. How many moles of oxygen will be required to completely burn propane?

(A) 4 moles (B) 5 moles

(C) 3 moles (D) 6 moles

ANSWER KEY

1	C	**2**	D	**3**	C	**4**	B	5	C
6	B	**7**	C	**8**	B	**9**	A	10	B

QUESTIONS FOR SHORT ANSWERS

2. Questions for Short Answers

Q.1 Differentiate between an organic and an inorganic compound.

Ans: **DIFFERENTIATION**

The differences between mole and **Avogadro's number** are as follows:

Organic Compound	Inorganic Compound
• Hydrocarbons and their derivatives are called organic compounds.	• Compounds other than hydrocarbons and their derivatives are called inorganic compounds.
• Naturally occurring **organic compounds** are obtained from **plants and animals**.	• **Inorganic compounds** are obtained from **minerals and rocks**.
• **Organic compounds** have **low melting and boiling points**	• **Inorganic compounds**, on the other hand, have comparatively **high melting and boiling points.**

Q.2 Why are organic compounds found in large numbers?

Ans: **LARGE NUMBER OF ORGANIC COMPOUNDS**

Organic compounds are large in number due to the following reasons:

- Catenation
- Isomerism
- Strength of covalent bond between carbon atoms
- Multiple bonding

Q.3 Name the products which are obtained when natural gas is oxidized under controlled conditions.

Ans: **PRODUCTS OF OXIDATION OF NATURAL GAS**

A wide variety of products are obtained when natural gas is oxidized under controlled conditions.

Example

Methanol, propanol, and formaldehyde.

Q.4 How naphtha fraction is decomposed to give lower hydrocarbons?

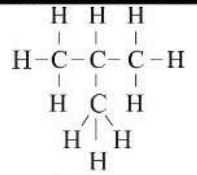
Ans: **DECOMPOSITION OF NAPHTHA**

Naphtha fraction is decomposed to give lower hydrocarbons by a process called cracking. Cracking is the breakdown of larger hydrocarbons into smaller ones by passing over catalyst in the absence of air or oxygen.

Q.5 Write down the molecular formula, structured formula and the condensed structural formula for iso-butane.

Ans: **FORMULAS OF ISO-BUTANE**

Following are the molecular, structural and condensed formulas of iso-butane:

Molecular Formula	Structural Formula	Condensed Structural Formula
C_4H_{10}	 isobutane	$H_3C-CH(CH_3)-CH_3$

Q.6 How are organic compounds useful for us?

Ans: **USE OF ORGANIC COMPOUNDS**

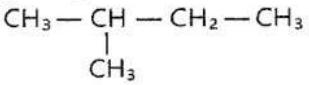
Q.7 Write down the names of five such organic compounds which exist naturally?

Ans: **NATURAL ORGANIC COMPOUNDS**

The names of five such organic compounds which exist naturally

- Benzene
- Methane
- Acetylene or ethyne
- Methanol
- Toluene

Q.8 Give IUPAC name to the following compound.



Ans: **IUPAC NAME**

Its name is 2-Methyl –butane.

Q.9 How do the melting and boiling points of alkane change when we move from lower members to higher members?

Ans: **TREND OF M.P. & B.P. OF ALKANES**

When we move from lower members to higher members, the melting and boiling points of alkane increase gradually due the increase in molecular masses of the alkanes.

CONSTRUCTED RESPONSE QUESTIONS

3. Constructed Response Questions

Q.1 Why do alkanes show little reactivity towards the other reagents?

alkanes show little reactivity towards the other reagents due to the presence of saturation i.e. carbon-carbon single bonds.

Ans: **LITTLE REACTIVITY OF ALKANES**

Q.2 Why does a mixture of natural gas and air explode?

Ans: **EXPLOSION OF NATURAL GAS AND AIR**

A mixture of natural gas and air explodes because when natural gas burns with oxygen, a highly exothermic reaction takes place which releases large amount of heat in the form of explosion.

Q.3 How do you compare the melting and boiling points of inorganic and organic compounds?

Ans: **COMPARISON OF M.P. & B.P.**

Q.4 The comparison between **the melting and boiling points of inorganic and organic compounds** are as follows:

Organic Compounds	Inorganic Compounds
• **The melting and boiling points of organic compounds** are low due to the weak intermolecular forces of attraction. Due to weak attractive forces between molecules it is easier to separate the molecules from each other.	• **The melting and boiling points of inorganic compounds** are higher due to the strong electrostatic force of attraction (ionic bond). Due to strong attractive forces between particles we have to heat to greater extent to separate the particles from each other.

Q.5 Reactions of alkanes with chlorine takes place in the presence of sunlight. What is the role of sunlight in the reaction?

Ans: **ROLE OF SUNLIGHT**

Sunlight provides the energy needed to start the reaction between alkanes and chlorine. It breaks the chlorine molecule into highly reactive chlorine radicals, which react with alkane molecule in a reaction called substitution reaction.

Q.6 How do you compare the boiling point of n-butane with that of iso-butane?

Ans: **COMPARISON OF M.P. & B.P.**

The comparison between **the melting and boiling points of n-butane and iso-butane** are as follows:

n-butane	Iso-butane
Trend	
• It has higher boiling point as compared to iso-butane.	• It has lower boiling point as compared to n-butane.
Reason	
• n-butane has a straight chain structure, which allows for stronger intermolecular forces compared to the branched structure of iso-butane	• iso-butane has a branched chain structure and thus weaker intermolecular forces of attraction .

Q.7 Why are organic compounds not generally soluble in water?

Ans: **INSOLUBILITY OF ORGANIC COMPOUNDS**

Organic compounds are not generally soluble in water because most organic molecules are non-polar while water is a polar solvent, so they cannot form strong intermolecular interactions with water molecules and remain insoluble.

DESCRIPTIVE QUESTIONS

4. Descriptive Questions

Q.1 Describe the importance of organic compounds in daily life.

Ans: **IMPORTANCE OF ORGANIC COMPOUNDS**

Organic compounds are part of everything, from food we eat to the various items we use in daily life to fulfill our needs. Organic compounds are prepared naturally as well as synthetically by chemists.

(i) Uses as Food:

The food we eat daily such as milk, eggs, meat, vegetables contain carbohydrates, proteins, fats, vitamins, etc. are all organic stuff.

(ii) Uses as Clothing:

All types of clothing (we wear, we use as bed sheets etc.) are made up of natural fibres (cotton, silk and wool, etc.) and synthetic fibres (nylon, dacron and acrylic etc.) all these are organic compounds.

(iii) Uses as Houses:

Wood is cellulose (naturally synthesized organic compound). It is used for making houses and furniture of all kinds.

(iv) Uses as Fuel:

The fuels we use for automobiles and domestic purposes are coal, petroleum and natural gas. These are called fossil fuels. All of these are organic compounds.

(v) Uses as Medicines:

A large number of organic compounds (naturally synthesized by plants) are used as medicines by us. Most of the life saving medicines and drugs such as antibiotics (inhibit or kill microorganisms which cause infectious diseases) are synthesized in laboratories.

(vi) Uses as Raw Material:

Organic compounds are used to prepare a variety of materials, such as rubber, paper, ink, drugs, dyes, paints, varnishes, pesticides, etc.

Q.2 Why is carbon so important as an element that the whole branch of chemistry is based on it?

Ans: **IMORTANCE OF ORGANIC COMPOUND**

Carbon is so important as an element that the whole branch of chemistry is based on it because of its unique ability to form stable bonds with itself and other elements which allows to form a vast variety of complex, large molecules. These molecules are the building blocks of all life forms on Earth.

Q.3 A carbon-carbon single bond does not behave as a functional group but a carbon -carbon double bond (C = C) does. Explain.

Ans: **FUNCTIONAL GROUP**

Carbon-carbon single bond is not afunctional group because it is the structural feature of many of the classes of organic compounds, whereas carbon carbon double bond is a functional group because it is the specific property of unsaturated compound, especially alkenes.

Q.4 Explain IUPAC system of nomenclature for alkanes.

Ans: **IUPAC NOMENCLATURE FOR ALKANES**

Answer given on page # 289, 290

Q.5 How combustion reaction of alkanes is useful for us?

Ans: **USE OF COMBUSTION OF ALKANES**

Combustion reaction of alkanes is useful for us because it produces heat energy which is use for heating purposes **in houses, automobiles, industries etc.**

INVESTIGATIVE QUESTIONS

5. Investigative Questions

Q.1 When natural gas valve is kept open in the kitchen, the gas spreads through the whole kitchen. This may cause an explosion. What is the reason of this explosion and how can you avoid it?

Ans: **REASON FOR EXPLOSION OF NATURAL GAS**

An explosion occurs due to accumulation of gas in the kitchen. When this gas mixes with air and encounters an ignition source such as a spark, flame, or electrical discharge, the gas reacts and causes an explosion.

How to Avoid Explosion?

Install gas detectors in gas areas or kitchen

Regularly monitor and service the gas detection equipment

Q.2 NEEM is a common tree grown throughout our country. Comment on the medicinal benefits of this tree.

Ans: **MEDICINAL BENEFITS OF NEEM**

- Neem has an anti-inflammatory property which helps to reduce reduces acne.
- It also helps to reduce skin blemishes.
- Neem is a rich source of Vitamin E and helps to repair damaged skin cells.
- It has antifungal property which helps to treat fungal infections.

Besides all these a lot of other medicinal benefits of Neem are.

Q.3 Name a few popular medicines which are, in fact, organic compounds?

Ans: **MEDICINES WHICH ARE ORGANIC COMPOUNDS**

A few popular medicines which are, in fact, organic compounds are as follows:

- Atorvastatin
- Fluticasone
- Clopidogrel
- Biologics such as infliximab, erythropoietin, insulin glargine

TERMS TO KNOW

Terms	Definitions
Organic compounds	The compounds obtained from plants and animals were named as organic compounds. Fredrich Wohler was the first chemist to prepare an organic compound in the laboratory,
Organic chemistry	Organic chemistry is the chemistry of carbon compounds. The element carbon is unique in its behaviour.
Properties of Organic compounds	Organic compounds are covalent in, nature. Their melting point and boiling points are generally low.
Hydrocarbons	Organic compounds containing carbon and hydrogen are called hydrocarbons They

	ate classified into saturated and unsaturated hydrocarbons.
Saturated hydrocarbons	Hydrocarbons containing a Single bond between carbon and hydrogen are called saturated hydrocarbons.
Alkanes	Alkanes can be named by a systematic way of nomenclature called IUPAC system of nomenclature.
Preparation of Alkanes	Alkanes can be prepared by a number of different methods of preparation.
Reactions of Alkanes	Although alkanes show least reactivity towards other compounds, they react With halogens and undergo combustion reactions.