



HYDROCARBONS

Student Learning Outcomes (SLOs)

After completing this lesson, the student will be able to:

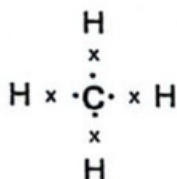
- State that bonding in alkanes is single covalent and that alkanes are saturated hydrocarbons.
- Describe the properties of alkanes as being generally unreactive, except in terms of combustion and substitution by chlorine.
- State that in a substitution reaction one atom or group of atoms is replaced 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 to mono-substitution.
- Describe, using symbol equations, preparation of alkanes from cracking of larger hydrocarbons, hydrogenation of alkenes and alkynes, and reduction of alkyl halides

INTRODUCTION

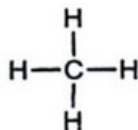
The simplest organic compounds are hydrocarbons. Organic compounds that contain only two elements, carbon and hydrogen, are called hydrocarbons. There are many types of hydrocarbons. They are classified according to the type of bond between the carbon atoms. In the previous chapter, you learned the differences between alkanes, alkenes, and alkynes.

14.1 ALKANES

Alkanes are saturated hydrocarbons. They have general formula C_nH_{2n+2} . Each carbon atom forms four bonds and each hydrogen atom forms only one bond. So the simplest alkane molecule that is possible is CH_4 . It is called methane. Methane is the main component of natural gas. Electron dot and cross structure for methane is as follows.

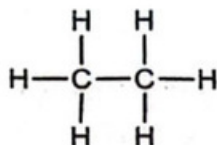


So the structural formula for methane is



Recall that structural formula shows which atoms are bonded to each other. The next member of alkane series is ethane, C_2H_6 .

Ethane molecules has following structure

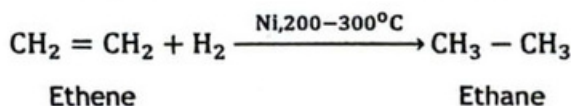
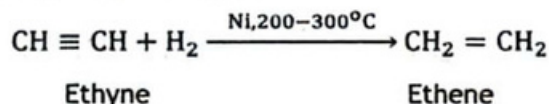


14.2 GENERAL METHODS OF PREPARATIONS OF ALKANES

1. By the hydrogenation of alkenes and alkynes

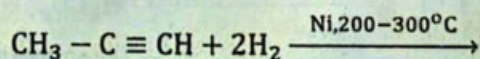
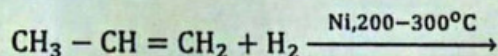
Addition of hydrogen molecule across carbon-carbon multiple-bond is called hydrogenation. Hydrogenation takes place in presence of finely divided nickel at $200 - 300^\circ\text{C}$ and high pressure. Hydrogenation can also be done in presence of Pt or Pd at room temperature.

Alkynes add two molecules of hydrogen. Why?



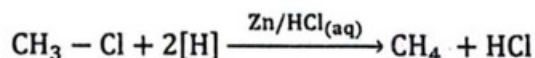
CONCEPT ASSESSMENT EXERCISE 14.1

Complete the following reactions



2. By the reduction of alkyl halides

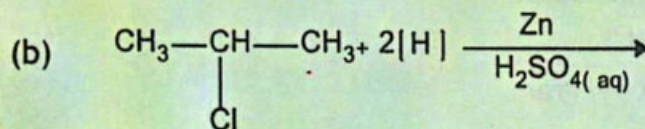
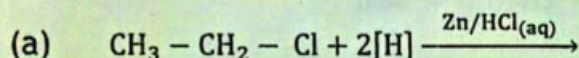
When an alkyl halide is treated with Zn in presence of an aqueous acid, an alkane is produced. Usually aqueous solution of HCl or CH_3COOH is used.



Zn reacts with aqueous acid to liberate atomic hydrogen called nascent hydrogen. Nascent hydrogen reduces alkyl halide. Addition of nascent hydrogen is called reduction.

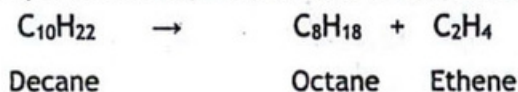
CONCEPT ASSESSMENT EXERCISE 14.2

Complete the following reactions.



3. By the cracking of larger hydrocarbons

A large hydrocarbon (alkane) molecule breaks into smaller hydrocarbons when heated at high temperatures such as $450-750^\circ\text{C}$ and high pressure. This process is called thermal cracking. This process produces a mixture of alkanes and alkenes. For example, when decane is heated at high temperature and high pressure, it breaks down into octane and ethene.



14.3 PROPERTIES OF ALKANES

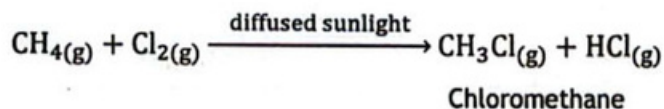
Alkane molecules are essentially non-polar. They are less dense than water and do not dissolve in it. Chemically, alkanes do not react with most ionic compounds. The lack of reactivity makes them useful solvents. For example, hexane is used to extract vegetable oils from corn, soybeans, cotton seeds, etc. Alkanes containing up to four carbon atoms are colourless and odourless gases. Alkanes, containing five to seventeen atoms, are colourless and odourless liquids. Higher alkanes are solids that are also colourless and odourless.

1. Halogenation

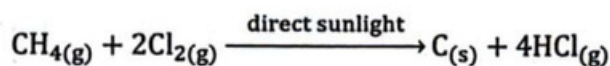
Although unreactive towards ionic substances, alkanes readily react with halogens in sunlight. A chemical reaction that takes place in presence of sun light is called as photochemical reaction.

The reaction of an alkane and a halogen is a **substitution reaction**. In this reaction a halogen atom substitutes for one or more of the hydrogen atoms of an alkane.

For example the reaction of methane and chlorine in diffused sunlight occurs as follows.



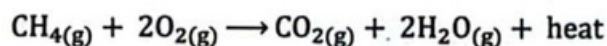
In direct sunlight the reaction of methane with chlorine is explosive and forms carbon and HCl.



2. Combustion

A reaction of a substance with oxygen or air that causes the rapid release of heat and the appearance of a flame is called **combustion**. Complete combustion of an alkane produces carbon dioxide, water and heat. Most of alkanes burn with blue flame.

For example, following reaction occurs when natural gas is burned.



The lighter alkanes are widely used as fuel. This is because:

- (i) Their combustion can be controlled.
- (ii) They produce large amount of heat per gram.
- (iii) They are cheap and readily available.

Incomplete combustion occurs in presence of limited supply of oxygen. Incomplete combustion of methane gives CO, C and H₂O.



KEY POINTS

- Hydrocarbons are compounds that contain carbon and hydrogen only.
- The simplest hydrocarbon that is possible is CH₄.
- Alkanes are generally unreactive
- Alkanes are saturated hydrocarbons
- In a substitution reaction one atom or a group of atoms is replaced by another atom or a group of atoms.
- Addition of hydrogen molecule in an unsaturated hydrocarbon is called hydrogenation.

References for additional information

- Longman chemistry for IGCSE.
- Chemistry, Addison, Wesley. Fifth Edition.

REVIEW QUESTIONS**1. Encircle the correct answer.**

- (i) Which molecule contains a carbon-carbon single bond?
(a) Ethane (b) Ethene
(c) Ethyne (d) Methanol
- (ii) Which product is obtained when chloromethane (or methyl chloride) is reduced?
(a) Ethane (b) Ethene
(c) Methane (d) Ethyne
- (iii) By hydrogenation we mean, the addition of
(a) Hydrogen (b) Water
(c) Halogen (d) Hydrogen halide
- (iv) Combustion of methane produces
(a) Carbon dioxide (b) Water
(c) Heat (d) All of these
- (v) Reduction of chloromethane gives
(a) Hydrogen (b) Chlorine
(c) Methane (d) All of these

2. Give short answer.

- (i) Give three examples of saturated hydrocarbons.
(ii) Draw structure for ethane.
(iii) Draw structural formulas of an alkane containing five carbon atoms
(iv) What do you mean by hydrogenation reaction? Give one example
(v) What is meant by cracking?
3. Discuss methods for the preparation ethane.
4. Describe properties of alkanes.
5. Write a chemical equation to show the preparation of an alkane from an alkene and an alkyne.

THINK TANK

6. Write chemical equations for the preparation of propane

